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A HANDBOOK FOR SCIENCE CLUBS

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BY

MISS K. SEN GUPTA

PUBLICATION COMMISSIONED BY UNESCO

OFFICE OF THE VIJNAN MANDIR,
ARIYAGOWNDANPATTI.

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MISS K. SEN GUPTA

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OFFICE OF THE VIJNAN MANDIR,
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A Hand Book for Science Clubs of India.

FOREWORD.

The purpose of the Hand Book is to help the sponsors and members of Science Clubs in India in their general activities to develop scientific thought and culture.

The primary aim of the Science Clubs will necessarily be to tend and foster a spirit of inquisitiveness in the minds of young children and to incite and inspire them to probe into the mysteries of nature with a robust will to search for truth by following scientific methods. The clubs are intended mainly to create and develop a scientific attitude of mind in their members rather than to function as agencies for supplying exhaustive information.

This book is the result of the varied experiences in the conduct of Science Clubs for girls at the Lady Irwin Higher Secondary School, Delhi, and was originally intended to serve as a guide for girls' clubs. Nevertheless it will be useful for all science clubs.

I am thankful to the senior science staff of my school without whose help it would have been difficult for me to bring out this book. I am specially thankful to Mr. M.L. Bhatia for helping me in various ways in the preparation of this book and in seeing it through the press.

The Hand Book is being published with the assistance of U.N.E.S.C.O. The purpose of that great organisation will be adequately served and the labours of the writer amply rewarded if it proves to be helpful to those for whom it is meant.

Miss K. Sen Gupta
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School for Girls, New Delhi.

July 1953.

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CHAPTER 1.

How to Organize and conduct a Club?

(i) What a sponsor does.

The sponsor is responsible for gathering round himself a group of children and for creating urge in them to try out scientific methods in interpreting nature. Although he will always try to keep himself in the background and give importance to the office bearers of the club, he remains the real motive force behind the club. Working imperceptibly but with unfailing zeal he should keep watch on the tempo of the club, and whenever signs of slowing down appear he should promptly create an atmosphere for accelerating it. Constant feeling of the pulse and creating an atmosphere for keeping interest alive in the members are the real job of the sponsor.

Science and Domestic Science teachers in schools are best fitted for being sponsors. As they are trained in child psychology, they are in a better position to inspire children than others. Any degree student in Science or Domestic Science who is generally popular with the school children is also fit to be a sponsor. Retired school or college teachers with special interest in children's activities are suited for the purpose. Besides, any one interested in Science and having a natural affection for the school children and regard for their potentialities may also serve as a sponsor, The sponsor should treat every member of the club with respect and try to give him every facility for carrying out the project of his choice and express appreciation for his work whenever it is due.

(ii) How to start a Club.

2. Get into touch with at least five members who are keen on learning or doing something more than what they do in their schools. The membership may go up to thirty. Members should be chosen from the age group of nine to twelve for junior clubs, and thirteen to eighteen for Senior Clubs. It is better not to enrol too many members in the beginning, as otherwise it will be difficult to maintain cohesion in the initial stages. Again, it is desirable to confine the

activities mainly to observations and experimentations. Lectures may be required only to explain the methods followed in such observations and experimentations. It is possible that lectures may be interesting to some members but unless and until the members are initiated to actual carrying out of projects, they cannot acquire skill of execution and ability for arriving at correct conclusions.

(iii) Where does the club meet.

Find a meeting place for the club. Most probably the school practical class rooms will be available, if the sponsor happens to be a teacher in the school. If the sponsor is a college student, the college in question may be available. In the case of the sponsor being a retired school or college teacher, the school or college to which he was previously attached may serve as the meeting place. If the sponsor is not connected with any educational institution, any suitable educational institution in the locality from which some of the members have been enrolled may be sounded for the purpose failing which a room in any house of the locality may be obtained through the good offices of the supporters of the club. It is essential that the place chosen should remain open to the members on fixed days and between fixed hours to enable them for carrying out observations and experiments.

(iv) What is done in the first meeting of the Club.

Office-bearers of the Club should be elected at the first meeting. Decide on membership fee. Decide on the place of subsequent meetings.

Have a list of five or six groups of projects ready, so that members may at the very first meeting decide on the project they would like most to work on. It is advisable not to attempt more than five or six projects at a time, and it would be better to choose one project from each of the different branches of Science. More than one member should be encouraged to work on any selected project. It is better to have four or five members working on the same project. Each member working on the same project should work individually but should be encouraged to compare notes periodi-

cally with other members working on it. This will enable them to establish cordial relations and harmony in their work of observation and to acquire skill in experimentation and accuracy in interpretation through mutual co-operation. They will find that though the same methods are applied by the individual members, their results vary. It is most important to realise that the variations are often due to the degree of efficiency with which the project is handled.

Meetings should be held fortnightly and should be attended by the members. The progress made by different groups working on different projects may be discussed and consolidated reports on the work done on each project may be presented in the meetings. Ten minutes may be allotted for reporting on a project and ten minutes for discussions on it, so that if there are three projects the meeting will be over in one hour,. Business may take a few minutes more. The time limit should not, however, be rigidly enforced. It should better be left to the discretion of the office-bearers who should, of course, see that members do not waste time. Meetings should not, however, be made to continue longer than two hours. The clubs that are working on more than three projects, will give the members opportunity to speak on the remaining projects at the next meeting. Each group should be given equal and impartial treatment.

General meetings of the club should be held periodically. The dates and times on which the general meetings will be held should be planned and notified a month ahead to members during the meetings. Ordinarily only the members of the club will take part in the meetings but distinguished scientists may be invited to address meetings whenever necessary. The management of the club should better be entrusted to its members only, the sponsor acting as an adviser.

(v) Duties of the Sponsor and the Office-bearers of the Club.

The office-bearers and the Sponsor of the Club are responsible for framing its general policies and their proper execution. They should meet before each formal meeting to make sure that all items of business are kept ready for consideration and to chalk out the programme of the club in advance, as far as possible.

The office-bearers and their duties should normally be as follows:—

President:- The President will preside over meetings and be responsible for the administration of the Club with the advice and counsel of the Sponsor.

Secretary:- The Secretary should keep permanent notes of all business and programmes. He is also held responsible for calling meetings of the Club from time to time.

Treasurer:- The Treasurer should keep accounts and be responsible for all moneys. He should spend money with the permission of the Sponsor up to a specific amount decided on by the executive committee from time to time.

The Club Reporter:- The Club Reporter should collect and gather report from Sponsor, office-bearers and members of the club, and should write a concise report giving due prominence to all the important points. He would try to contact the editors of the local papers and try to give publicity to the work of the Club. He should send copies of the report to different schools to be published in their school magazines.

The Club Librarian:- (a) The Club Librarian is responsible for collecting reports of work on each project and have them carefully filed and kept in the Club Library.

(b) He should also see that all other materials and equipments of the Club are carefully kept before and after use.

Assistant Secretary:- The Assistant Secretary should work in the absence of Secretary, and should help him otherwise.

(v) Short Training Course.

While the club will be progressing, you may find that some members feel that their knowledge and skill are not quite adequate for the project they had chosen. Short courses of training may do them good. You may arrange such short courses for them with the help of the following agencies which exist for the public welfare and will be only too glad to instruct you in their special fields free of charge:—

1. Municipality Health Services, such as
   - (a) Child clinic.
   - (b) Maternity centres.
   - (c) Centres for prevention of malaria.
   - (d) Centres for prevention of tuberculosis.
   - (e) Centres for prevention of contagious diseases.
   - (f) Centres for the care of eyes, teeth etc.
   - (g) Food and Dietetics centres.
   - (h) Squads for fighting household pests.

2. Red-Cross Society, Junior and Senior.

3. Local nursery.

4. Grow-more-plants squads.

5. Locust fighting squads.

7. Forest and soil preservation centres.

8. Official and unofficial centres for preservation of fruits and vegetables.

9. Educational agencies sponsored by the Directorate of Education :
   - (a) Adult education centres.
   - (b) Community project centres.
   - (c) Audio-visual educational squads.

10. Public welfare Organizations of State Ministries.

11. Managers of Public Libraries.

12. Organizers of Charitable Dispensaries.

13. Institution run by Ramakrishna Mission.

There are other agencies which may also be interested in your work and may help you. Foreign Embassies are in your country for promoting good will and friendship between your country and theirs; they may help you in these matters, if properly approached. You may contact their Cultural Attache to make sure whether they are interested in your work.

Local Science and Domestic Science colleges and Technical Institutions may also come to your help by arranging free course of training for your members. University Professors and teachers may arrange for courses of training either by themselves or through their students.

Winter and autumn holidays are best suited for such lectures but summer holidays can also be utilised. Lectures can be arranged at other times as well, when there is need for them.

(*vi*) *Excursions.*

Excursions must be well-planned and be, to be really useful, conducted under an experienced guide. A visit to the following places will be useful to the members of Science Clubs.

1. Local Dairies. 2. Local Bakeries. 3. Fisheries. 4. Orchards. 5. Granaries. 6. Agricultural Fields. 7. Irrigation system. 8. Botanical Gardens. 9. Any well kept garden with the permission of the owner. 10. Ponds and Aquariums. 11. Potteries. 12. Carpenters' workshops. 13. Black-smiths' workshops. 14. Weavers' workshops. 15. Jewellers' workshops. 16. Petrol pumps. 17. Automobile Repair Plants. 18. Fire-Brigade Stations. 19. Police Stations. 20. Post and Telegraph Offices. 21. Telephone Exchange. 22. Radio Stations. 23. Water Works. 24. Electric Power House. 25. Mints. 26. Museums. 27. Zoos. 28. National

Archives. 29. Railway Stations. 30. Aerodromes. 31. Dock-yards. 32. Ship-yards. 33. Boat-yards. 34. Medical Colleges. 35. Hospitals. 36. Doctors' Clinics. 37. Engineering Colleges. 38. Agricultural Colleges. 39. Refugee Rehabilitation Centres. 40. Mills and Factories. 41. Workshops of Technical Institutions. 42. Laboratories. 43. Blind Schools. 44. Deaf and Dumb Schools. 45. Schools for retarded children. 46. Reformatries. 47. Jails. 48. Photographers' shops. 49. Printing presses. 50. Banks.

The above list is not exhaustive; it is only illustrative. All the above - mentioned places may not be available in your city or village, but your members should visit as many works of scientific interest in your city or village as possible. Holidays may be utilised for the purpose. These visits should be taken when the members have free time. It is not advisable to go for excursions too often. It will be enough if one or two such excursions would be organized in a month.

(*vii*) *Social Functions, Picnics and Hikes.*

In social functions the members may themselves prepare and serve the teas. They may invite other Science Clubs of the locality so as to make friendly acquaintance with their members. This may be followed by a talk or demonstration on any scientific subject.

Picnics and hikes should be mainly meant for having good time and fun so that members may have opportunity to know each other more intimately. Work will be more enjoyable and stronger ties of friendship will bind the members together as a result of such pleasure parties. Collection of specimens will of course take place on such occasions.

(*viii*) *Publicity.*

The main object of getting publicity is twofold: firstly, to get help and advice from competent persons, and, secondly, to secure the services of members for the club, who by their enthusiasm will be its mainstay and by their work and enterprise will make the club a success. Publicity if done in an efficient manner will inevitably draw a certain amount of public support for the propagation of science in

general and may create conditions in which Government help may be easily forthcoming. It is, therefore, essential that you get publicity.

Your club member in charge of publicity should approach all the leading newspapers and seek advice of the news editors in the matter of publicizing your club activities. One of the surest ways of getting occasional publicity is to invite, from time to time, at your functions some of the distinguished personages of the country, whose activities the newspapers are eager to publicize. If such notable persons are pleased with your work, they may express favourable opinion before the gatherings and their words which will undoubtedly carry a great weight are sure to get publicity in the press. This is one of the effective ways of popularising your club organisation to the general public.

Your publicity member may also send brief monthly reports to the editors of Science Magazines so that if any of them proves to be interesting and useful, they may publish it on the pages of some of the issues of their magazines.

But the best and surest way of getting general recognition and creating good will is of course by helping your neighbours by doing service to them by scientific methods and appliances. This responsibility devolves on all the members of your club and not on your publicity officer alone.

Your may induce all the children of your locality and through them their parents to take adequate precautions against malaria, cholera, typhoid and other common infectious diseases before the season of such diseases actually sets in. You may also arrange for popular talks on various scientific subject with the help of a magic lantern or an epidiascope. You may even ask your members to give talks on the projects they are working on.

In a sense this will give more publicity than the newspaper reports. A particular news item may escape the notice of its readers but whoever will attend your lectures is likely to take home some

impression about the methods you have explained, and this will induce even a person of unscientific bent of mind to think in terms of science.

Your school magazine and the school notice board should have a corner for your activities.

Do good solid work in your Science Club and publicity will be within easy reach.

(ix) How to Conduct a Science Fair.

Your Club should have a Science Fair once a year and in addition to it, it may also take part, if it has a chance to do so, in the Inter - School or International Science Fair. The date and time for the science fair to be sponsored by your Science Club should be fixed at least six months in advance, so as to give the participators enough time to prepare for it.

The Science Fair may have two sections. In one section a good representation of all the activities of your Science Club may be given, and in the other only the exhibits of members competing for prizes may be kept. The competition may be open to all of the same age group so that any one of a particular age group may join. The age group may be nine to ten, eleven to twelve, thirteen to fourteen and fifteen to sixteen. The number of prizes allotted to each group may be at least three or in case of more than thirty entrants 10% of the number of entrants. Prizes may be in the shape of medals capable of being kept permanently so that the members winning them may preserve them for life.

Try to make the prize-distribution ceremony as imposing as possible. Try to get a distinguished persbackup to give away the prizes in the presence of an appreciative gathering, so that the winners may receive sufficient encouragement. The idea behind this is that if they receive due encouragement, they may one day aspire for the highest scientific honour.

Persuade some distinguished citizens well conversant with the particular branches of science on which competitions are held, to act

as judges and, with a view to getting their judgement, make neeessary arrangements to show them round a day or two before the fair is thrown open to the public. Charge a nominal entrance fee and contact all the schools and colleges and persuade their students and teachers to visit the fair.

(x) *Funds and Finances.*

Funds are necessary for your club. You are, therefore, to devise means for collecting funds, in addition to membership fee and monthly subscription. You may sell the articles your members have prepared; preserved fruits, jam, jelly, pickles, laundry box with all the laundry requisites, first--aid boxes and sewing boxes which are expected to be of more improved quality than those available in the market, may easily find the market. Sweets and eatables may be sold in tea-stalls in fairs and exhibitions arranged by the club. Some kinds of vegetables and fruits when they are cheap and available in sufficient quantity may be cleaned and dried in the sun for sale at seasons when they are not available. Your own members may buy them for home consumption. Woollen and cotton garments, embroidered articles, useful household articles made from waste materials, toys — scientific and ordinary, miniature microscopes, telescopes, radios, telephones, electric fans, electric motors etc., may also be prepared and sold in the market. The sale of such articles will fetch some money and augment the funds of the club.

(xi) *Donation.*

People interested in your work may be asked to donate for your club funds. The institutions visited by your members may also like to donate in kind for your Club laboratory and museum. Glass factories may donate test-tubes, jars and beakers, and metal factories clamps, stands and metal vessels. Nurseries, orchards and Botanical gardens may supply you with specimens for your gardens. Grow-more-food squads may supply manure and better types of seeds. Pamphlets and publications, if any, issued by the organizations visited by your members may be available, free of charge. Some of them may be quite interesting and be added to your Club library. Carpenters, blacksmiths and potters whose shops have

been visited by you may offer to do for your club jobs at cost price. Printing presses may offer you concessional rates, news papers and publishers may offer to give publicity to your work without any charge. These direct and indirect ways of financial assistance from various sources may serve to build up the funds of your clubs.

(*xii*) *The neighbourly spirit.*

After the club is sufficiently consolidated and made to work satisfactorily for some time, tremendous enthusiasm will undoubtedly grow among most of the members. These members should be encouraged to start branch clubs in their localities. They may secure the services of one of the elders in their locality as their helper. It may also be possible to get into the work some retired ladies or gentlemen who might have been connected during their active service with one or the other branch of science. Similarly some of the college students of the locality who after they have done their degree course and not yet been fixed up in their career may be persuaded to utilise their time in helping your members as long as possible. Less ambitious members should be encouraged to help their neighbours. The percentage of school-going children in India beyond the primary stage is very small. Therefore on those few who go beyond the primary stage rests the responsibility of improving the lot of the nation. As citizens of free India they should take active interest in her people and problems. To begin with, your members may help their neighbours to run their house more economically by eliminating wastage of all kinds. They may be shown the methods of cooking food by keeping all its food value in tact, of conserving coal and fire-wood by constructing better and more scientific ovens, of getting the full benefit of the food they eat by inculcating in them the habits of eating balanced meals, of avoiding illness by obtaining personal cleanliness, and taking adequate physical exercise.

Neighbours may be shown the methods of growing better vegetables by proper use of manures and fertilizers, and by taking adequate care against animals and insects.

Members may give talks to the children of their neighbours to which the parents of the children may be invited. For such talks

the epidiascope of their own club may be had on loan and made use of on such occasions. Talks on the following subjects may be useful and interesting :–

1. Prevention of malaria. 2. Life history of mosquitoes. 3. Prevention of tuberculosis. 4. Scabies. 5. Diseases caused by unbalanced diet. 6. How do the following habits spread diseases:–

(a) Spitting.

(b) Eating and drinking from the same vessel.

(c) Using the same towel.

(d) Not segregating a person suffering from common cold, cough, and infectious diseases.

7. How to take care of babies generally and at teething time particularly.

Some subjects of common interest may also be chosen for talks: solar and lunar eclipses, full moon and new moon days are days of religious observance in most parts of India, and these may, therefore, form the topics of the talks. There are many other topics of common interest.

If you have succeeded in inspiring your members to take to the fascinating methods of observation and experimentation, you should think that you have done your duty well. Further if you have been able to inculcate in them the spirit of helping their neighbours, you have surely achieved your object and your labours have been doubly crowned.

CHAPTER II

PART I

PROJECTS IN BIOLOGY

(For junior members of a science club)

1. Germination of Seeds:—

(a) Examine some common seeds viz. maize, paddy, peas, beans and seeds of any other plant and note the different parts of each. You will find that some seeds have only one seed leaf and others have two seed leaves. Group them into groups accordingly. Select some seeds of the first group, soak them in water and put them in a glass vessel. Line the glass vessel with a piece of damp blotting paper and fill it with damp sand or saw dust. Do likewise with some seeds of the second group in another glass vessel. Watch the germination. Compare the germination of the first group with that of the second.

Note the following:—

(i) From where the seed roots come out.

(ii) Whether it grows downwards, whatever the position of the seed.

(iii) How does the seed shoot grow?

(iv) What happens to the seed leaves as the seed plant grows?

(v) When do the tiny leaves of the seed shoot open?

(vi) When do they turn green?

(vii) Is there any difference between the seed roots of the two groups of seeds?

(viii) Not the veins of the leaves of the seedling. Note the difference between the two groups. Make a series of drawings in your record book showing successive stages in the process of germination and note down your remarks.

(b) Repeat the experiment (a) up to the stage the seed shoot comes out. Break off the seed leaves, watch the growth of seed plant. The plant dies.

Conclusion:—Something very necessary for the growth of the plant has been taken away.

(c) Repeat the experiment (a) upto the stage that shoot leaves turn green. Break off the seed leaves. Watch the growth of the seed plant It grows normally.

Conclusion:—Seed leaves are no longer necessary for the growth of the plant.

(d) Select dicotyledonous seeds as gram, pea and mango and try to germinate them in the soil, in a pot or box. Note the number of days they take to germinate. When shoots are seen above the ground observe them daily and make records of daily change by the help of drawings. Note the position of the seed leaves whether it is above or under the ground.

(e) Select Monocotyledonous seeds as paddy and maize and observe the changes in these as in (d),

(f) Select dicotyledonous seeds as bean, gourd, tamarind and castor. Observe the changes as in (d). Note the differences that you see between these seeds and seeds of the group in (d).

(g) Select monocotyledonous seeds of Onion. Observe the process of germination. Note the differences from the seeds of the group (e).

2, *Conditions necessary for germination:—*

When seeds germinate in the natural conditions, we find they need water and enjoy Oxygen, light and normal warmth. Let us see whether all these are necessary for germination.

(a) Put a few dry seeds on cotton wool in two test tubes 'A' and 'B', the cotton wool being dry in 'A' and wet in 'B', Keep both tubes in a warm room so that the seeds in 'A' have air and warmth, but no water, while these in 'B' have air, and warmth and water.

Note what happens after a few days in a warm room. Record your observation and conclusion.

(b) Put a few similar seeds in a test tube 'C' containing air-free water (prepared by boiling some water to drive out the dissolved air and then cooling it under a layer of oil to stop air entering again). Keep this tube 'C' with tube 'A' and 'B' in a warm room, so that the seeds in 'C' have water and warmth, but no air, while those in 'B' have water, warmth and air. Compare 'B' with 'C' after a few days. Record your observation and conclusion in your record book.

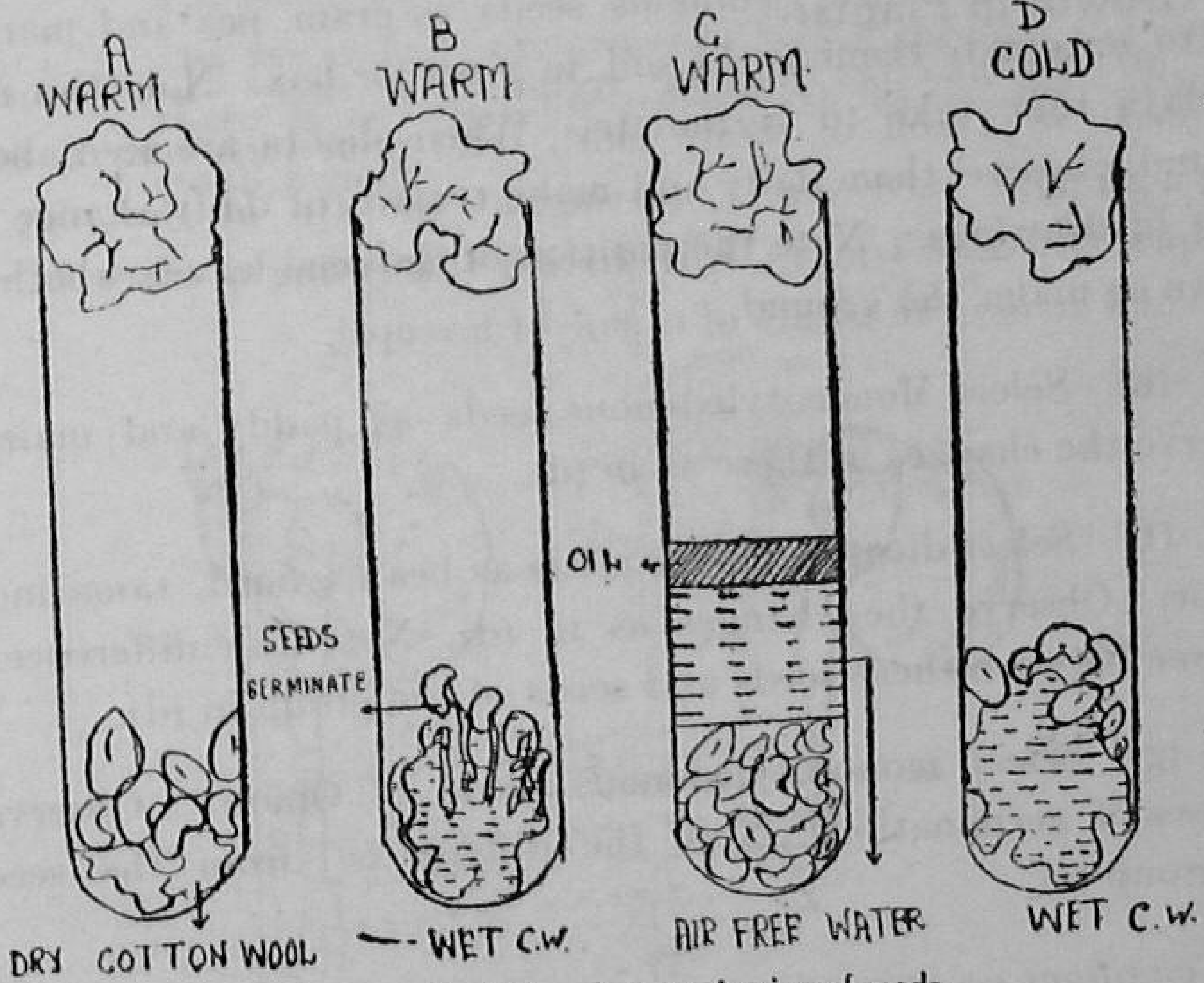

Fig. 1. Conditions for germination of seeds

(c) Put a few similar seeds on wet cotton wool in a test tube 'D' and keep the tube in an ice box (or moderately cold refrigerator) for a week so that the seeds in 'D' have water and air but little warmth, while those in 'B' have water, air and more warmth. Compare 'B' with 'D' after a week. Record your observations and conclusion in your Record Book.

(d) Repeat the experiment (c) by keeping the test tube 'D' in a bath of high constant temperature. Record your observation and conclusion in your Record Book.

(e) Repeat the experiment (c) this time putting the test-tube 'D' in a dark cup-board or a box. Record your observation and conclusion :—

(i) What difference do you notice in colour?

(ii) What difference do you notice in the size of the leaves?

N. B. For these experiments if test tubes are not available bottles or pots can be used.

3. Growth in Plants:—

(a) *To find the growing region of a root:* Let some seeds germinate in a roll of damp cloth and then pick out a seedling with a straight seed-root. Starting at the tip of the root, mark off equal spaces of 1 m. m. with Indian Ink (using a piece of thread stretched across the points of a pair of forceps).

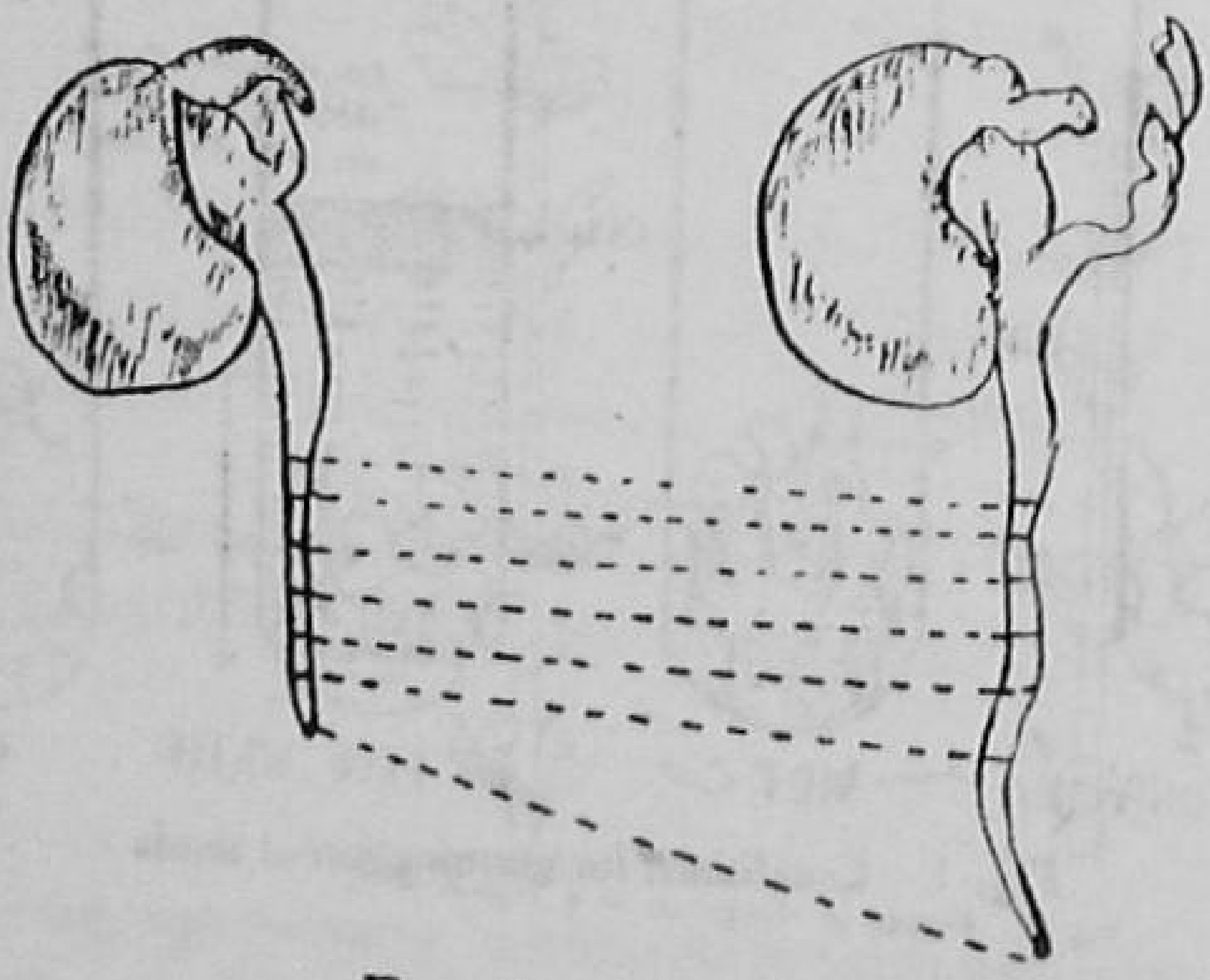

Fig. 2. Growth of a root.

Now put the seedling between the glass and the damp blotting paper of a germination vessel and look at it every few hours.

Q. What do you notice as the root grows?

Q. Which marks become wider apart?

Conclusion:— Growth is rapid in the region where the marks are widest apart.

(b) *To find the growing region of a stem:—* We can find out where growth takes place in the stem in the same way. Mark off

the main stem of a growing seedling with Indian Ink, putting the marks 5 m. m. apart, and look at it every few hours.

Q. What do you notice as the stem grows?

Q. Which marks have become wider apart?

N. B. Growth in stems is spread over a considerable length of the young stem, as shown in fig. 3., and is not limited to a very short region just behind the tip as in roots. The stem, unlike the root, does not have to overcome any resistance as it grows in length through thə air, so there is no need for its growth to be limited to one small region.

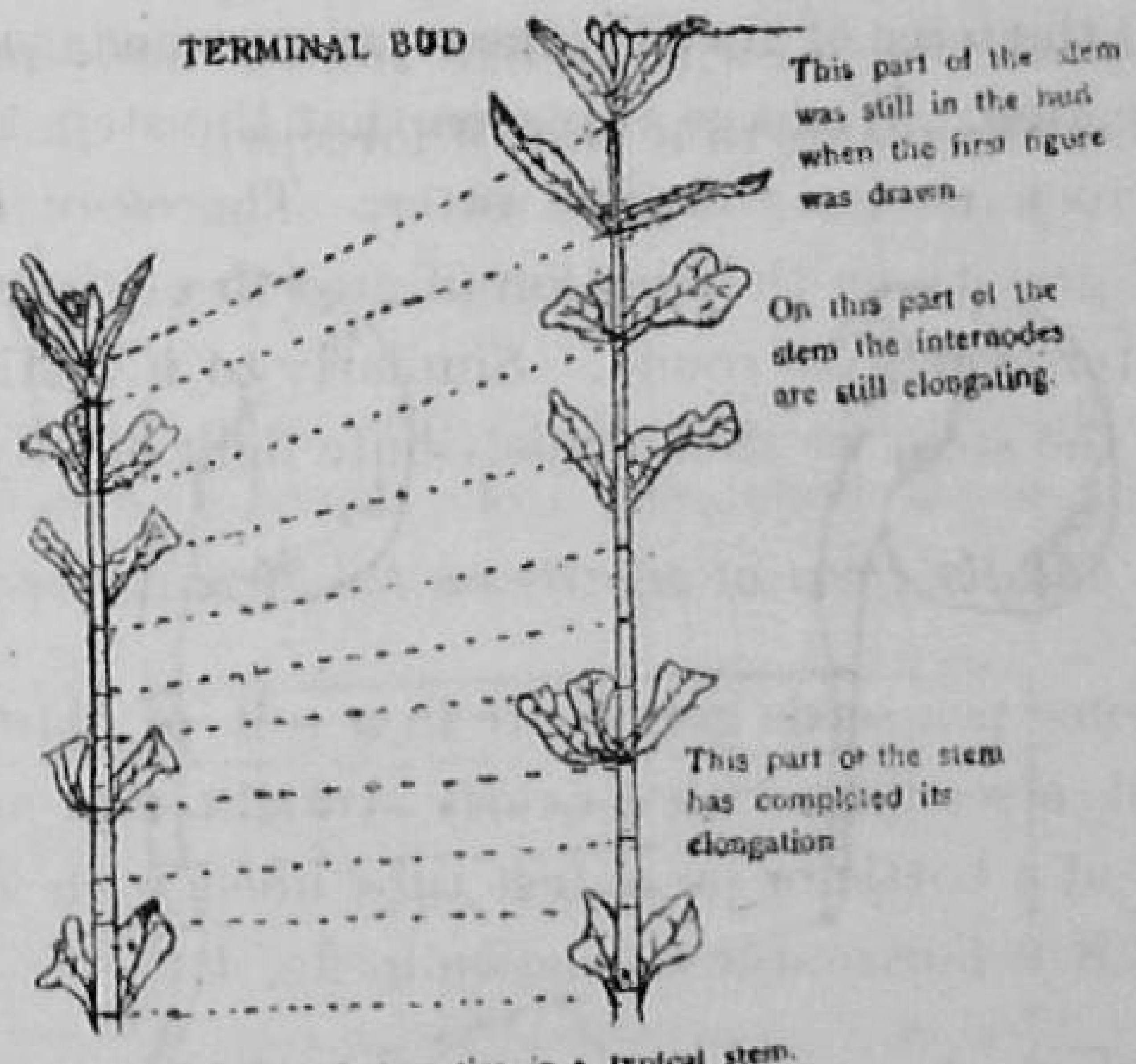

Fig. 3 Region of elongation in a typical stem.

(c) Brick walls and concrete drains are often crackd by the roots of neighbouring trees.

How and Why?

N. B. Growing roots can exert a considerable force.

As the tip of the root is pushed through the soil, the outer layer gets worn away. If an undamaged root tip is examined with a lens, we find that the root tip is protected by a root cap usually less than 1 m. m. long. The root tips of many water plants and

the air roots of orchids show well marked root caps because they are not worn away by being pushed through the soil. Roots growing in soil usually have their root caps rubbed smooth, and they can only be seen by cutting a very thin slice from the tip of the root and examining it under a microscope. As the root forces its way through the soil, the outside is worn away, but it is always being renewed from the growing point inside, just behind the root tip.

Examine root caps of Screwpine, Water plants, Orchids etc.

4. The Direction of Growth in roots and stems:—

We have seen that in whatever position the seed is planted, the main root always grows downwards and the main stem always grows upwards. It is inferred that in each case the direction of growth is the result of the force of gravity, the stem growing against it and the root in its direction. We have also seen that the stem moves towards light and the root moves towards water. Therefore to investigate the effect of gravity on the dirction of growth of the root we should distribute water evenly all round. Similarly to investigate the effect of gravity on the stem we should distribute light evenly all round.

(a) *To find the effect of gravity on the direction of growth of the root :—*

Let some pea seeds germinate in a roll of damp cloth, and then pick out a seedling with a nearly straight root and stem. Pin it to the cork of a bottle or large test tube lined with damp blotting paper so that it is horizontal, as shown in fig. 4.

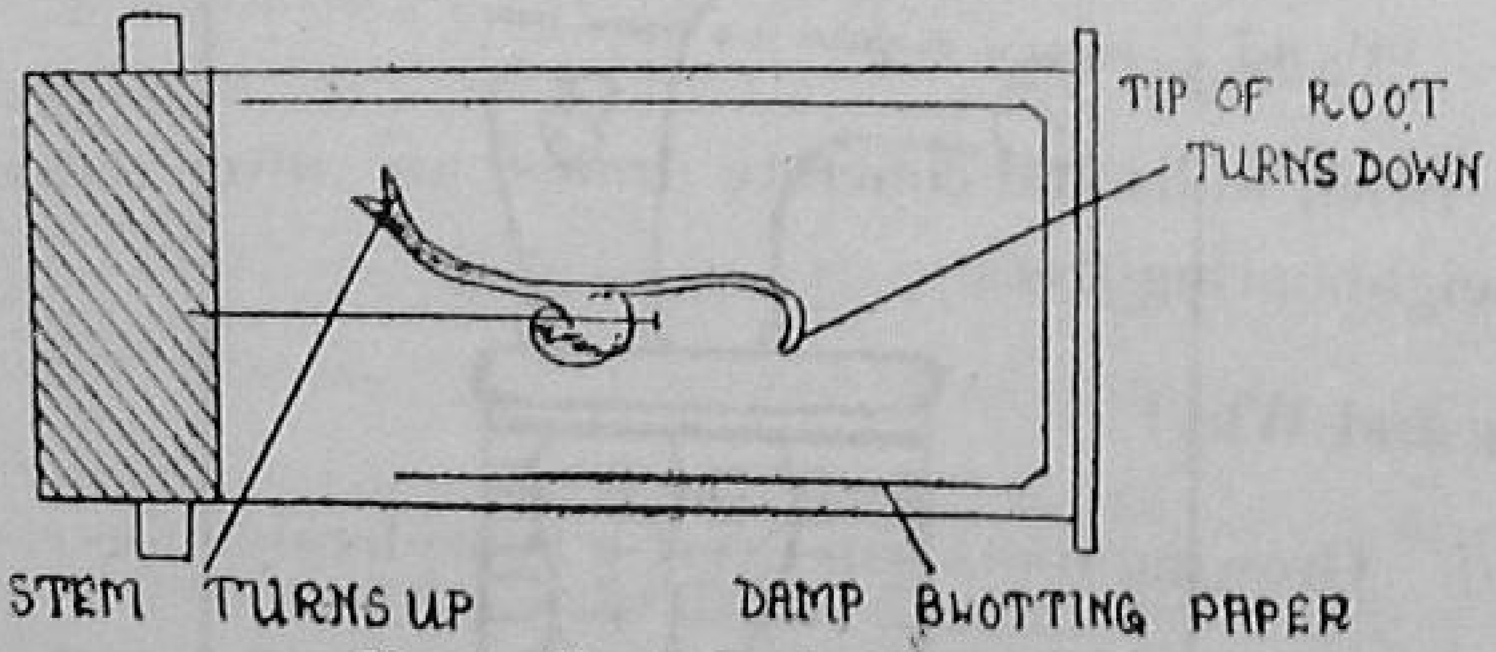

Fig. 4. To study the effect of gravity.

Put the vessel in dark place and look at it every hour.

Observe the direction of the growth of the root, and make a note of it in your Record Book with the help of sketches.

N. B. In this experiment, the root gets no light, so it cannot be said that it is merely turning away from the light. Also, since the vessel is lined on all sides with damp blotting paper, it cannot be said that the root is merely turning towards water. The only force which has acted on the root from below is the force of gravity. Therefore the conclusion arrived at is definite.

(b) *To find the effect of gravity on the direction of growth of the stem* :—

Observe the direction of growth of the stem in the last experiment, and make a note of it in your Record Book with the help of sketches.

N.B. As the seedling was kept in the dark and was equally damp on all sides the effect of water on the root and that of light on the stem is eliminated. The effect of gravity can be observed.

(c) *To find the effect of light on the direction of growth* :—

Place a piece of coarse cloth stretched across the mouth of a glass vessel, kept damp by hanging one end of the cloth in the

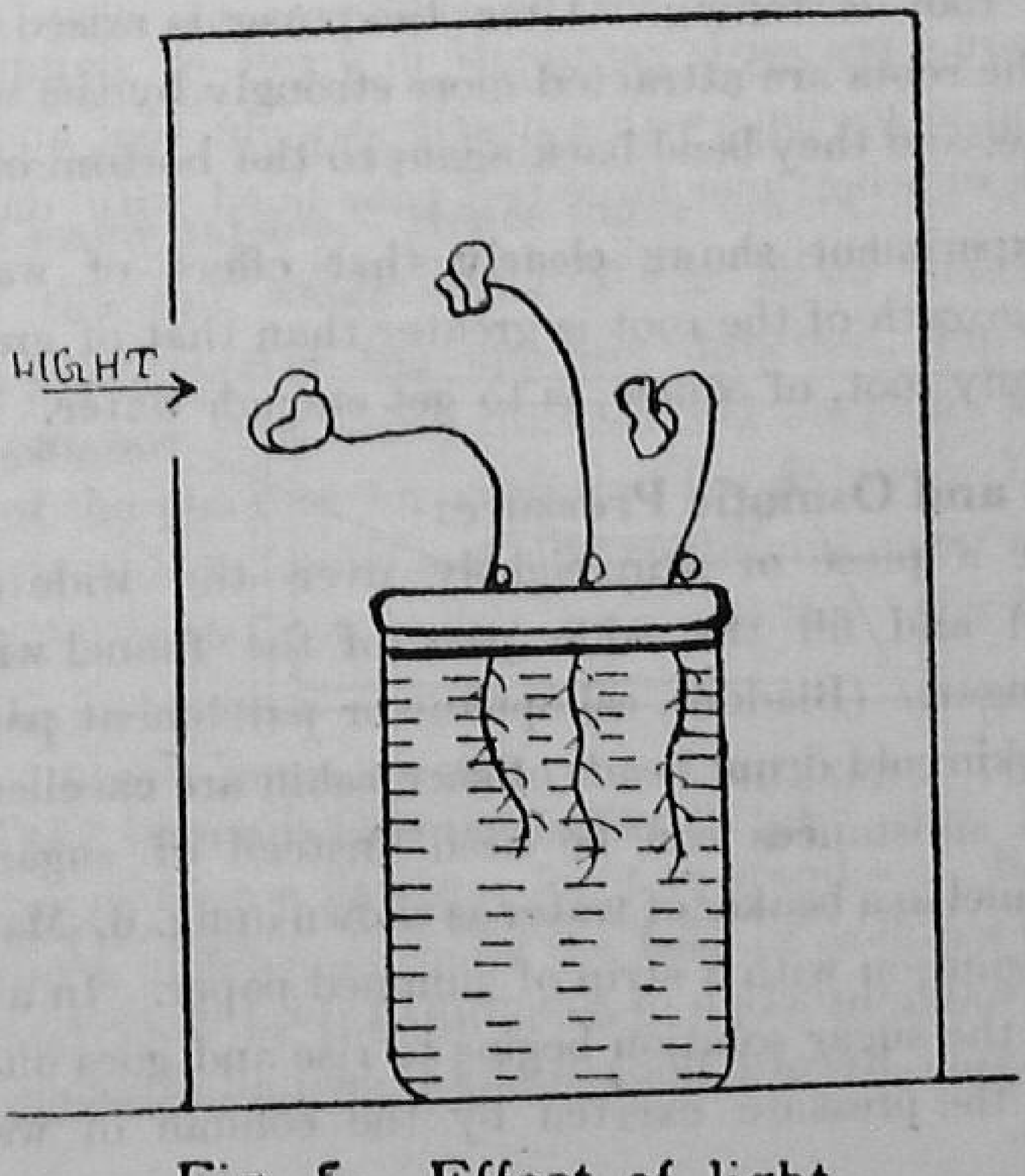

Fig. 5. Effect of light.

water inside the vessel. Put small seeds (peas) on the damp cloth and put the vessel inside a light-tight box provided with a small hole in one of its sides, as shown in Fig. 5.

After a few days note the following:—

(i) The direction towards which the stem grows.

(ii) The position of the green leaves.

Note (i) that these grow at right angles to the rays of light so as to receive the greatest amount of light (ii) also that the attraction of light is greater than the force of gravity. The first necessity of the stem is to reach light.

(d) *To find the effect of water on the direction of growth of roots:—*

Small seeds are sown in damp sand or saw dust over a wire gauze which is fixed at an angle, the whole being covered with a jar or tin so that the air inside is kept damp. After a few days remove the covering.

Observe the direction towards which the roots have grown. Draw a diagram and make a note of it. Observe also the change of direction the root is taking. After the cover is raised so as to let in drier air, the roots are attracted more strongly by the water above the wire gauze, and they bend back again to the bottom of the gauze.

This experiment shows clearly that effect of water on the direction of growth of the root is greater than that of gravity. The first need of any root, of course, is to get enough water.

5. **Osmosis and Osmotic Pressure:—**

(a) Tie a piece of skin tightly over the wide end of the thistle funnel and fill the wide part of the funnel with a strong solution of sugar. (Bladder, cellophane or parchment paper may be used for the skin; old drum heads of sheep skin are excellent). Many other soluble substances can be used instead of sugar. Support the thistle funnel in a beaker of water as shown in fig. 6. Mark the level of the sugar solution with a strip of gummed paper. In a short time the level of the sugar solution begins to rise and goes on rising day by day, until the pressure exerted by the column of water in the

tube becomes heavy enough to burst the skin. By using long glass tubes joined to the thistle funnel, it is easy to get a rise of over 10 feet. The height of this column of water measures the osmotic pressure of the sugar solution.

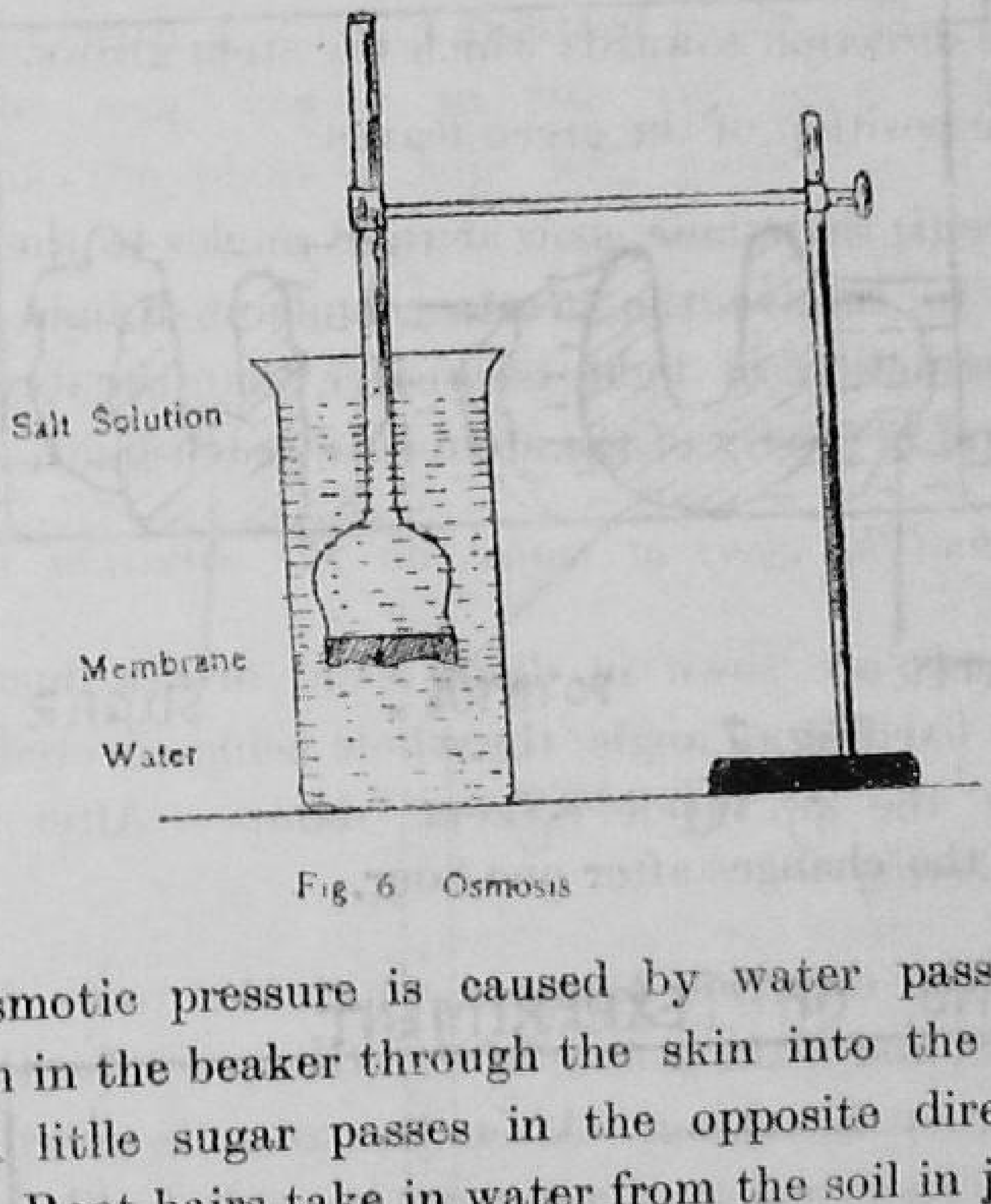

Fig. 6 Osmosis

The Osmotic pressure is caused by water passing from the weak solution in the beaker through the skin into the strong sugar solution. (A litlle sugar passes in the opposite direction at the same time). Root hairs take in water from the soil in just the same way, since the sap or liquid inside the root hairs is a stronger solution than the soil water outside. Hence water enters the root hairs by osmosis. If the soil water contains too much dissolved matter, osmosis may take place in the opposite direction, and water passes outwards from the root hairs, thus making the plant wilt (i. e., the green parts of the plant become soft and hang down). In the above experiment the thistle funnel and skin containing sugar solution, form a big 'working model' of a root hair, and the water in the beaker represents the soil water.

(b) Take 10 similar potatoes and cut off a slice from one end of each so as to form a flat base for it to stand on. Remove a ring of skin (about 1 inch wide) round the base of each potato, and then make a round hole in the top of each, down to about an inch from the base, as shown in fig. 7. (Make the hole with a large cork borer).

Stand the potatoes in a dish containing a little water. Put a few grains of sugar in the hole of one potato, and leave the hole in the other potato empty.

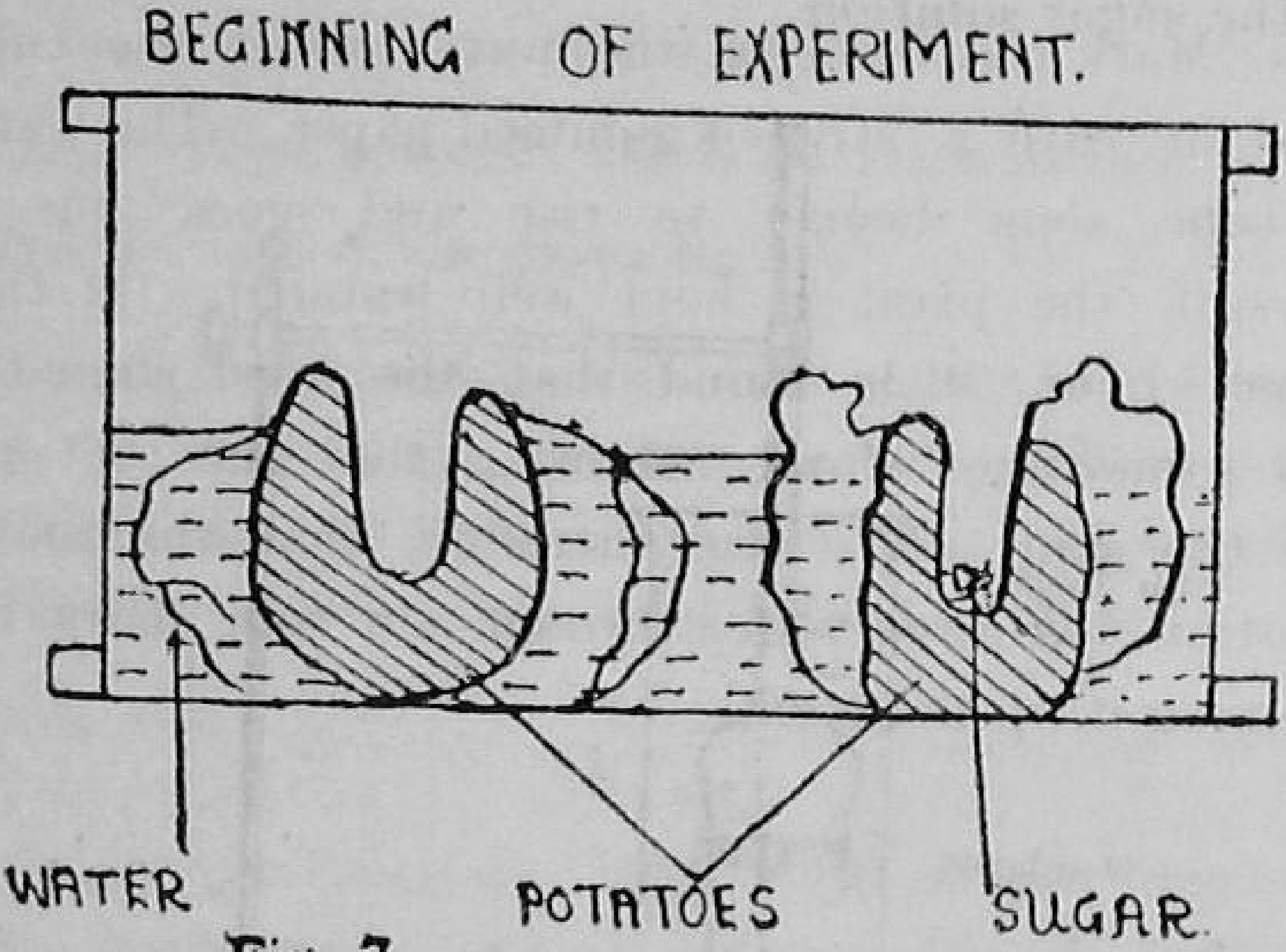

Fig. 7.

Observe the changes after one hour.

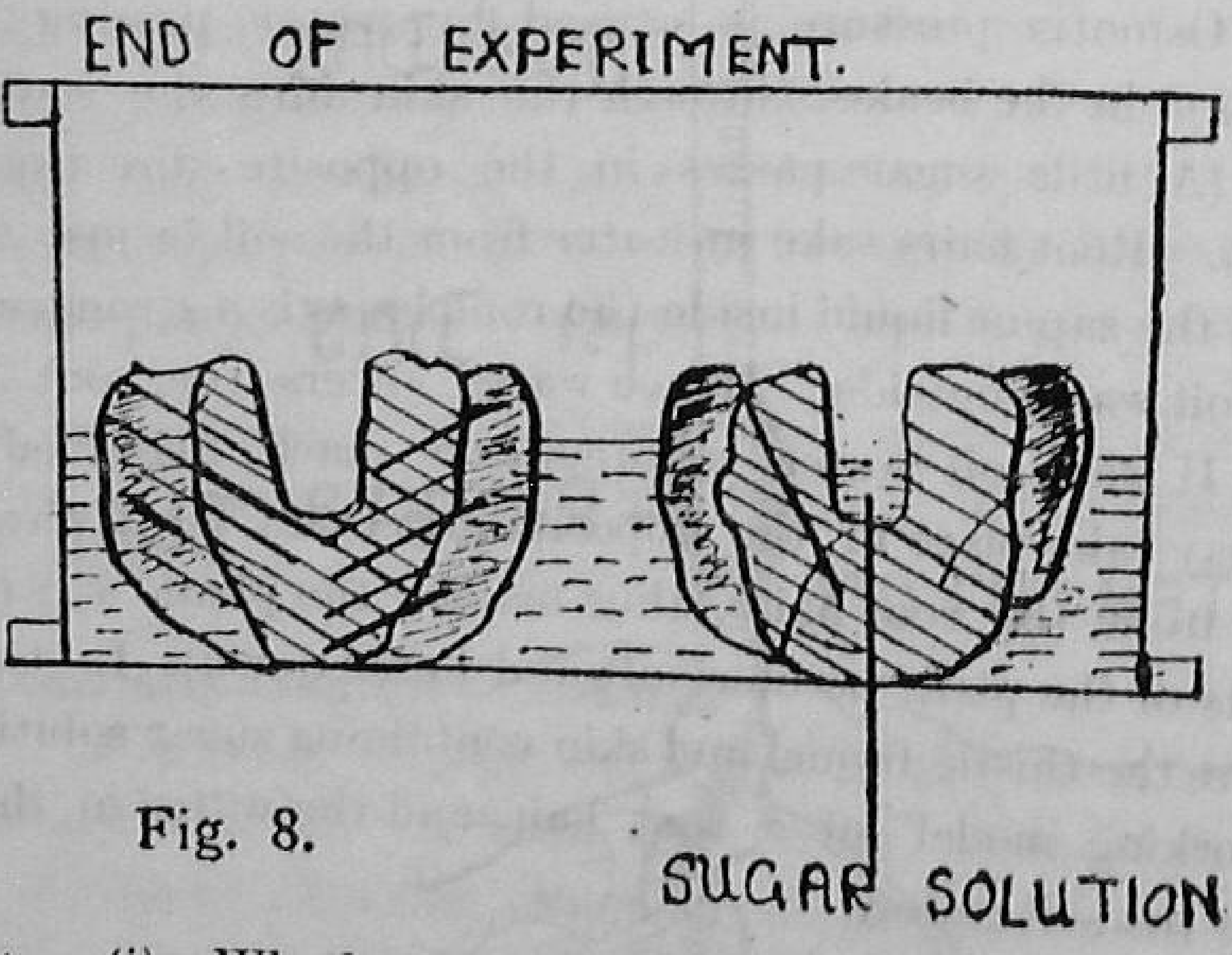

Fig. 8.

Note:—(i) Whether in the hole of the first potato any liquid collects.

(ii) Observe likewise the hole of the second potato.

Note down the reason for the difference.

(c) Cut the stem of a healthy Balsam plant just above the soil and at once fit a straight glass tube to it with thick rubber tube as shown in fig. 9. Pour a little water into the glass tube so as to keep the cut end of the stem wet at the beginning of the experiments. Mark the level of the water inside the tube with a rubber band or with a strip of gummed paper. The water level in the glass tube soon begins to rise and goes on rising for several days if the plant is kept well watered. If the level is marked every hour, it is found that the level some-times rises quickly and some-times slowly, showing that the root pressure is not always the same. We see, therefore, that the root acts as a pumping station, taking in water through its root hairs by osmosis and then forcing it up the stem.

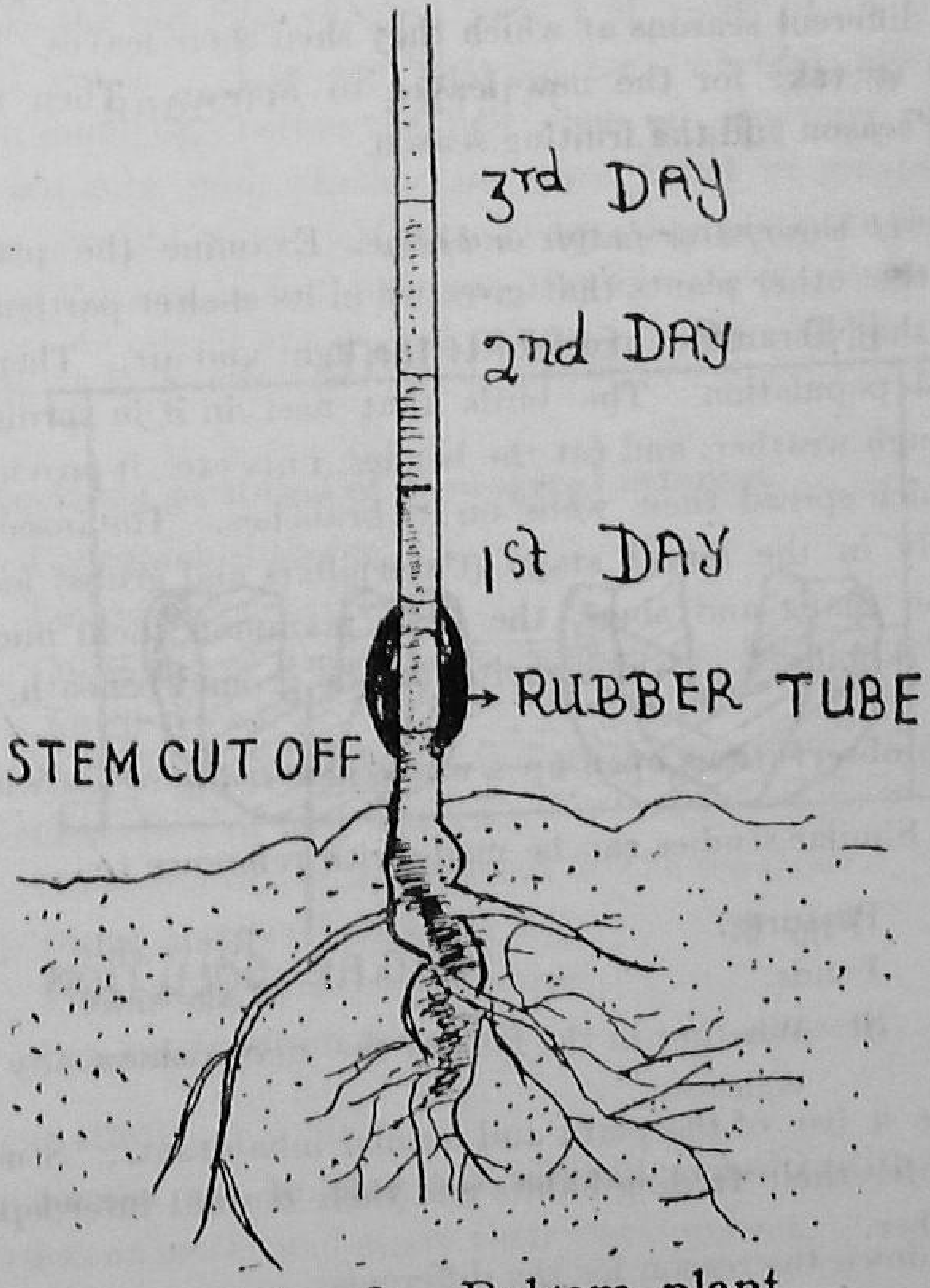

Fig. 9. Balsam plant

Life in General.

1. **General Observations of Biological Interest. Observations to be made:—**

Make records in your Nature Calendar according to the localities in which you live.

(a) *If a city* – Visit famous gardens during the flowering season and become familiar with the seasonal flowers of that area. Try to collect them, press them, name them and make an album.

Make a note of the common trees, shrubs and herbs. Collect the various kinds of leaves and press them.

Make a note of the trees grown on road side to give shade. Note the different seasons at which they shed their leaves. Note how long will it take for the new leaves to appear. Then mark the flowering season and the fruiting season.

(b) *If a forest or jungle or hedge* – Examine the plants that form it, the other plants that grow up in its shelter particularly the climbers that scramble over it to the light and air. Then there is its animal population. The birds that nest in it in spring, shelter in it in rough weather, and eat the berries, nuts etc., it provides. The spiders which spread their webs on its branches. The insects which particularly in the larval stage (Caterpillars and grubs) feed on its leaves, the snails and slugs, the little mammals (field mice, hedge hogs even rabbits etc.,) which shelter in the ground beneath.

Such observations open up a whole new realm of knowledge.

(c) Similar studies can be made with reference to:—

Pastures.
Ponds.
Streams.
River side.
Lake side.
Sea shore.

Make a list of the plant and animal inhabitants. Study their ways of life, their feeding habits and their mutual interdependence on each other.

(d) Visit the fields and make a record of the main crops of that locality.

In all these recordings only the main and interesting things should be included.

(e) Visit the sea-shore when the fishermen draw their nets early in the morning.

(f) Visit vegetable markets and fish markets at different seasons of the year. Write down the names of fruits and vegetables and fishes available at these different seasons. Observe roots and stems and their different forms that are used as vegetables.

Make the record in the first year and verify it in the second and third years. Note any changes i. e., whether new varieties have been found or whether the new ones are healthier and better than the old ones and whether they are found in greater number than the previous year. If there is any change, try to find out the reason and this can be well attempted by the senior group.

If there is deterioration, find out the reason for this also.

2. Collections of items of Biological interest.

1. Collection of leaves.
2. Collection of flowres.
3. Collection of fruits and seeds which are showing peculiarities for dispersal.
4. Collection of butterflies and their wings.
5. Collection of bird feathers.
6. Collection of sea shells found on the sea shore.
7. Birds' nests and eggs.
8. Fish scales of various patterns.
9. Sea urchins from sea shore.

3. Insect study.

Collect the eggs or caterpillars (larvae) of any insects, especially of butterflies or moths and study their development.

Purchase some silk worm eggs and study their growth and development.

Cockroach. Live Cockroaches are easily kept in a covered jam jar. They can be fed on bread and water.

It is rather an interesting pet as it occasionally assumes most comical attitudes, especially when cleaning its limbs. This they do somewhat after the fashion of cats.

4. **Worm study.** Pupils can study the earthworm in its natural environment. Observe and record the external features and mode of life.

To study the habits of earthworms we set up a Wormary in the following manner:—

Obtain a large bell jar or a rectangular glass dish about 12 inches deep. Invert the bell jar, place a few pebbles at the bottom, and then fill it with layers of differently coloured moistened earth. Garden soil, sand and leaf mould afford a good contrast. With a fine brush and white paint make lines on the glass to mark the divisions between the different layers of soil. Place several healthy worms in the 'home' thus prepared. Scatter a few leaf fragments, or minute cubes of such vegetables as onion,. carrot etc., on the surface of the soil. Cover the top with butter muslin, and throw a black cloth over the whole.

Soon burrows will be made. Some of these are sure to be against the glass, and their size and shape can be examined. Notice also how the worms treat the various fragment of food you leave on the surface. Experiment with different kinds. Keep the soil always slightly moist. Notice how the lower layers of soil are brought up to the surface, until, in time, the various layers are quite indistinguishable.

Exercise:—Collect some worm castings, and notice how fine and powdery is the soil. Some of this soil is occasionally spread out by the worm to form a thin, smooth lining to the burrow. The animal smears it over the surface with its tail end.

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5. Fish study.

Some fishes can be kept in an aquarium and their external features, locomotion and mode of feeding can be observed.

If there is a Vivarium where we can keep birds and mammals, some common birds like parrot and myna and mammals like rabbit and guinea pigs can be kept and observed. Here again their external features, mode of feeding and locomotion can be observed.

6. Plan for flower gardens and vegetable gardens at home.

For flower garden choose the common flowers of the locality which will grow throughout the year. Have special plots for seasonal flowers.

For vegetable garden, choose plots with better soil and light. Grow vegetables of different seasons.

CHAPTER II.

Part II

PROJECTS IN CHEMISTRY

(For Junior Members of Club)

1. Air.

(a) *To find whether air exerts pressure.*

(i) Hold an empty beaker or an empty bottle with its mouth in water and at right angles to the level of water, and try to press it down.

1. Does water enter the beaker or bottle ?
2. Do you feel any resistance ?
3. What is your conclusion ?

(ii) Hold an empty bottle with its mouth upwards under water.

Note :

1. What happens while water enters the bottle ?
2. Do you see bubbles escaping from the bottle ?

(b) *To find whether air is necessary for burning.*

Light a candle and when it is burning steadily, place it on a platform; cover it with a clean and dry beaker in such a manner that the beaker's mouth is completely covered by the platform.

Note what happens ?

(c) *To study if air is a mixture of gases.*

Repeat the above experiment by putting the candle in a vessel that holds 2 to 3 inches of water. Cover the candle with a gas jar so that its edge just dips in water.

Note: (i) Whether water rises in the gas jar as the candle burns.
(ii) The level of water when the candle goes out?
(iii) What is your conclusion?

N. B.—The water could not rise in the gas jar unless it was rendered partially empty. The flame of candle had used up a portion of the air. But a part of air was still left out; it is, therefore, evident that the remaining air did not support burning. This proves that air is a mixture of gases.

(d) *To find whether air contains moisture.*

Put a clean dry glass on the table. Pour ice-cold water in it taking care that the outer surface of the glass remains perfectly dry.

Observe the outer surface of glass.

Note: (i) Whether drops of water appear on the outer surface.

(ii) Your conclusion.

(e) *To find whether air contains carbon dioxide.*

Keep some clear lime water in a vessel and expose it to the air for several hours.

Note the change of colour of the lime water. Record your conclusion.

Find out if your breath contains carbon dioxide. Take a test tube and add lime water to it. Blow air from your lungs in it through a tube. Note the change in the colour of lime water. It becomes milky. What do you conclude ?

2. **Water as a solvent.**

(a) Put some water in a glass or metal vessel and heat the vessel slowly till the water evaporates.

Note : Whether some sediment is left in the vessel. Record your conclusion.

(b) Take a little of water in a beaker and go on adding table salt to it. Continue the process till no more salt can be dissolved in it.

Note : (i) The weight of salt dissolved approximately.

(ii) The feeling of touch of the solution with your finger tips.

(iii) Taste.

(c) Repeat experiment (b) with sugar.

(d) *Formation of crystals.*

(1) Take a test fube; fill half of it with water, and add a little powdered copper sulphate to it. If it all dissolves, add a little more till no more can be dissolved. Heat the test tube slowly. Note what happens to the undissolved substance.

Allow the test tube to cool down slowly. Note whether you can detect any solid at the bottom of the test tube.

Let the test tube cool down for some time. Drain off the liquid carefully and put the deposited substance at the bottom of the test tube on a blotting paper.

Observe it under a magnifying glass.

Note : (i) Whether the substance is a powder,

(ii) Whether these are crystals.

(iii) Whether these are of the same size or of different sizes.

(iv) Whether these are of definite geometrical shape.

(2) Choose a crystal of copper sulphate obtained from experiment (d). Tie it to the end of a hair or thread and let it dip in a warn and strong solution of copper sulphate in a beaker. Let the beaker cool down slowly and undisturbed.

(i) Watch what happens to the crystal as the solution in the beaker cools down.

(ii) Watch the difference after some days.

(e) Try to get big crystals by the processes (1) and (2) of section (d) of the following substances :—

(i) Salt Petre.

(ii) Alum.

(iii) Lead Nitrate.

(iv) Mercuric Chloride.

(v) Nickel Sulphate.

(vi) Cobalt Sulphate.

(vii) Magnesium Sulphate.

(f) Put some crystals of copper sulphate in a test tube, and heat it slowly.

Note :—(i) Whether steam comes off.

(ii) Whether small globules of water appear on the cooler part of the test tube.

Allow the test tube to cool down.

Note the change in the crystals.

Explain the reason for the change.

(g) *Methods of separation.*

Given an indigo solution. Devise a method for getting pure water from it. (Hint.—Use the process of distillation.)

Repeat the same experiment with some other solution.

Can you separate indigo from the solution by filtering ?

(h) Devise means of separating the following mixtures:—

(i) Sand and salt.

(ii) Sand and sugar and iron filings.

(iii) Chalk and washing soda.

(iv) Sawdust, sugar and salt.

3. Hard and soft water:—

Soft water produces lather with soap easily, whereas hard water does not produce lather with soap.

Hard water is of two types: (1) temporary (2) permanent.

Temporary hardness is due to the presence of calcium or magnesium bicarbonates. Such hardness can be removed by boiling or by the addition of lime water.

Permanent hardness cannot be removed by the above-mentioned processes. It is due to the presence of calcium or magnesium sulphates or chlorides. Such hardness can be removed by the addition of washing soda (sodium carbonate).

Experiments on hard and soft water:-

(a) *Temporary hard water.*

Dissolve in a beaker containing water some calcium bicarbonate. You will get temporary hard water.

(i) Take a little of it in a test tube and add soap solution to it. See if any lather is formed.

(ii) Take in another test tube some more water from the beaker and boil it. Observe what happens. You will find a precipitate at the bottom of the test tube. Test the clear water left in the test tube, with soap solution. See if any lather is formed. What do you conclude from it ?

(iii) Take in another test tube some water from the beaker, and add lime water to it. Observe what happens. Test the clear water with soap solution. What do you observe and what conclusion do you draw from it?

(b) *Permanent hard water.*

Dissolve some magnesium sulphate in water in a beaker. You will get permanent hard water.

(i) Take a little of this sample of water in a test tube and add soap solution to it. Observe what happens. No lather will be formed.

(ii) Heat a little of this water in a test, tube and test it with soap solution. No lather will be formed.

(iii) Add lime water to a sample of this water in a test tube

and again test it with soap solution. No lather will be formed.

(iv) Take some water from the beaker in another test tube and add washing soda to it. Observe what happens. Test the water with soap solution. Lather will be formed. This shows that permanent hardness of water can be removed by adding washing soda to it.

Test different samples of water obtained from a river, a well, a spring and a tap, and decide which is soft and which is hard.

Can you suggest what type of water should you use for washing your clothes?

4. Acids and Bases.

(a) Take a little of dilute sulphuric acid in a beaker and put a drop of blue litmus solution in it.

(i) Note the change in colour.

(ii) Record the change in your record book.

(b) Repeat the same with:—

(i) Dilute hydrochloric acid.

(ii) Dilute nitric acid.

(iii) Dilute oxalic acid.

(iv) Citric acid.

(v) Acetic acid.

(c) Repeat experiments (a) and (b) with methyl orange and phenolphthalein.

(d) Take some dilute solution of ammonia in a beaker and put a drop of red litmus solution or a red litmus paper in it.

Note the change in colour, and record your observation in your record book.

(e) Repeat the same with:—

(i) Dilute caustic soda solution.

(ii) Dilute caustic potash solution.

(iii) Dilute sodium carbonate solution.

(iv) Dilute potassium carbonate solution.

A base turns red litmus blue.

(f) Repeat experiments (d) and (e) with methyl orange and phenolphthalein.

5. Chemical Tests.

(a) Take each one of the following substances in solution in a test tube and pass sulphuretted hydrogen through it and note the change in colour in each case.

(i) Lead Nitrate. (black).

(ii) Mercuric Chloride. (white, yellow, brown & black).

(iii) Copper Sulphate. (black).

(iv) Arsenic Chloride. (yellow).

(v) Antimony Chloride. (orange).

(vi) Ferrous Sulphate. (black).

(vii) Stannous Chloride. (black).

(viii) Zinc Sulphate. (white).

(ix) Nickel Chloride. (black).

(x) Cobalt Nitrate. (black).

(b) Take each one of the following substances in solution in a test tube and pour a little dilute ammonia solution in it.

Note the change in colour in each case.

(i) Silver Nitrate. (brown).

(ii) Copper Sulphate. (purple).

(iii) Ferrous Sulphate. (brown).

(iv) Nickel Sulphate. (blue).

(v) Cobalt Sulphate. (deep blue).

(vi) Manganese Sulphate. (brown).

(c) *To test the presence of starch.*

Dissolve some iodine in alcohol. Prepare a solution of starch and add a little of iodine to it. You will observe a purple colour. Test if potatoes, maize and rice contain starch .

(d) *To test the presence of sugar in a substance.*

For this purpose we have to use *Fehling's solution.* This test cannot be applied to ordinary sugar which is cane sugar. It can be applied to the sugar contained in fruits and vegetables.

In order to find out if orange juice contains some sugar, take some of it in a test tube and add Fehling's solution to it and heat the test tube. The colour of the solution will change from blue to orange in case some sugar is present in orange juice.

Find out if carrots, lemons, grapes and sweet lemons contain sugar.

6. Oil.

(a) Take some water in a test tube. Put a few drops of oil in it. Shake the test tube well.

(i) What do you notice ? What happens to the oil ?

(ii) What happens after a few minutes you stop shaking ?

(b) Repeat the experiment (a) with soapy water in the test tube and note:-

(i) What happens to the tiny particles of oil?

(ii) What happens after a few minutes the shaking is stopped?

(c) Repeat the experiment (b) with (i) yolk of eggs, (ii) gum acacia.

(d) Take a little of petrol in a test tube, and put a few drops of oil. Shake the test tube well.

Note:

(i) What happens to the oil ?

(ii) Whether you can distinguish the tiny particles of oil.

7. Removal of Common Stains.

(a) *Ink stains of cotton:-* Ink stain can be removed by treatment with a solution of oxalic acid. If it is not removed by oxalic acid alone, it may be treated with a dilute solution of potassium permanganate and then with oxalic acid. The cloth should be washed as soon as the stain is removed.

(b) *Coffee stains:*—A solution can be prepared from the following:—

Ammonium Chloride	...	2 parts.
Glycerine ...	...	2 parts.
Alcohol ...	...	2 parts.
Water ...	...	7 parts.

Treat the spot with this solution and then wash with soap.

(c) *Mil - dew*—

Hydrogen Peroxide 3%	...	16 parts.
Ammonium Chloride	...	4 parts.
Ethyl Alcohol. (rectified spirit)	...	10 parts.
Water ...	...	70 parts.

After treatment with the above solution, wash with water.

(d) *Iodine stains.* Apply 10% potassium iodide solution to the stain followed by a 10% solution of sodium thiosulphate until the stain is removed. Wash freely with water.

(e) *Iron stains:*—Wash the stain with 8% of potassium persulphate followed by water. It can also be removed by treatment with oxalic acid solution.

For other stains consult books.

8. How to distinguish a phyiscal change from a chemical change?

Physical Change:—

(1) Melt some ice in a beaker, and then boil some water in a flask. Note what happens in each case. In the first case, the

composition of water is the same as that of ice. In the second case the composition of steam is the same as that of water. These are physical changes involving no change in the composition of the substance formed.

(2) Rub a magnet several times over an iron needle and bring it near a small compass needle. Notice what happens, when each end of the needle is brought near the North pole of the compass needle. The iron needle has acquired new properties but its composition remains the same. It is a physical change

(3) Mix some sugar with water so as to form a solution. Taste the solution so prepared. Is it a physical change ? If so, why ?

(4) Mix some sulphur and iron filings together with a pestle and mortar. Bring a magnet near the mixture and observe what happens. Decide for yourself if it is a physical change, and why it is so.

(5) Attach a small torch bulb to the poles of a dry cell with a make and break arrangement in the circuit. Make the circuit and observe what happens to the filament of the electric bulb. Break the circuit and again observe what happens to the filament. The filament glows in the hot condition, and returns to the same state in the cold condition. Is it a physical change ? If so, why ?

Chemical Changes:—

(a) Heat some sulphur and iron filings together in a test tube. Observe what happens. Try to separate iron from the substance so formed with a magnet. Can you do it ? Iron cannot be separated from the new substance so formed. It is a chemical change involving the formation of a new substance iron sulphide with new properties.

(b) Take a water voltameter. Add water to it and add a few drops of sulphuric acid to the water, to make it a conductor of electricity. Fill the tubes with water and invert them over the electrodes. Connect the poles of a battery of three dry cells to the terminals of the voltameter through a key. Close the key and

observe what happens. You will get hydrogen in one test tube and oxygen in the other. Test each gas with a burning match stick. These gases have come from water. It is a chemical change involving the production of new substances.

(c) Take a piece of magnesium ribbon. Holding it with a pair of tongs, burn it with a spirit lamp. Light of dazzling brilliancy is emitted and a white powder is formed which is magnesium oxide. It is quite a new substance having properties entirely different from magnesium. What kind of change is it ? and why so?

(d) Take a test tube and put some red oxide of mercury in it. Holding it with a test tube holder, heat the tube. Bring a glowing splinter of wood near the mouth of the test tube. It will burst into a flame. The gas so produced is oxygen. Observe the sides of the tube and you will find globules of mercury sticking to it. Can you say what kind of change is it ? and why so ?

(e) Take a beaker, and put in it solution of copper sulphate and immerse two plates of copper in it. Connect these plates to the poles of a cell and close the circuit. Observe what happens to the plate connected to the negative pole of the cell. You will find a deposit of copper on it. Copper sulphate solution is decomposed by the current of electricity. Copper so set free is driven towards the plate connected to the negative pole of the cell, and is deposited on it. It is a chemical change. Can you say why?

(f) Take two test tubes and in one pour a solution of silver nitrate and in the other a solution of common salt. Add the solution of common salt to the solution of silver nitrate and observe what happens. You will get a white precipitate of silver chloride. Silver nitrate + Sodium chloride = Silver chloride + Sodium nitrate.

In this reaction, change of partners has occurred. It is a chemical change.

9. The Story of a candle.

(1) To show that when a candle burns, water and carbon dioxide are produced:—

Burn a candle and invert a gas jar over it such that seme air

continues to enter it from below. Examine the interior of the jar carefully. You will find some drops of water sticking to its inner surface.

Pour some lime water in the jar. Shake and observe what happens. The lime water will become milky showing the presence of carbon dioxide.

What is your conclusion about the structure of candle ?

The paraffine of which the candle is made contains hydrogen and carbon. When these elements combine with the oxygen of air, you get water and carbon dioxide. These substances pass into the air during the burning of candle.

(II) To study the structure of candle flame:—

Light a candle and examine its parts carefully. You will notice the following parts:—

(i) Zone of no combustion surrounding the wick.

(ii) Zone of partial combustion.

(iii) Zone of complete combustion.

(iv) Blue zone at the bottom.

(1) Perform the following experiments to show that there are unburnt gases in the *dark zone* surrounding the wick of the candle.

(a) Place a match stick in this zone. It will not catch fire.

(b) Place one end of a glass tube in this part and try to light the gas at the other end. Observe what happens. You will be able to light the gas at this end showing that in this region the gases do not burn.

(2) For studying the *zone of complete combustion*, bring a crystal of copper chloride near the flame. Observe what happens. The flame will become blue.

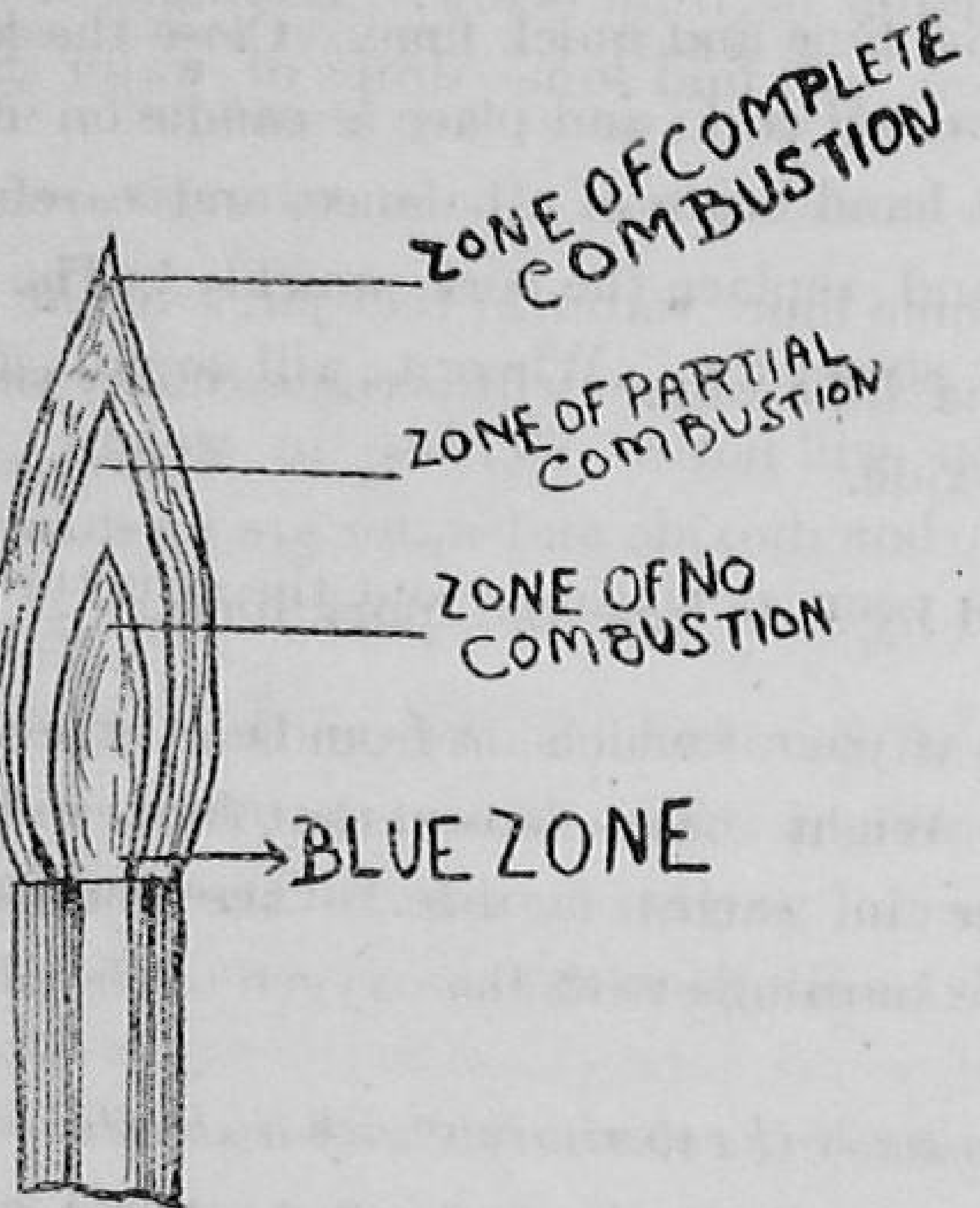

Fig. 10. Parts of candle flame.

Observe that this is a *non-luminous Zone*, and is the hotest part of the flame. In this region the carbon and hydrogen produced in the zone of partial combustion are completely oxidised to carbon dioxide and water.

Try the following experiment:—

Take a piece of porcelain and put it in the flame of the candle. It will be covered with soot which consists of carbon particles. In the cold condition these particles are black. But when these particles are heated, these become yellow. Hence we have the yellow portion of the candle flame.

Can you explain why the flame at the base is blue ? It is due to the burning of carbon monoxide.

(III) To show that when a candle burns nothing is lost:—

The above statement proves that *matter is indestructible.*

Take a wide glass tube and put inside it a copper gauze and

put on it soda lime and quick lime. Close the lower end of the tube with a perforated cork and place a candle on it. Support the tube from the left hand beam of a balance, and carefully weigh it. Light the candle and replace the cork quickly. The candle will continue to burn for sometime. When it will go out, allow the apparatus to cool. You will notice increase in weight. Due to the burning of candle, carbon dioxide and water are produced. These substances are absorbed by soda lime and quick lime.

What is your conclusion from this experiment ? There is no decrease in weight. This shows that the candle is not destroyed. The increase in weight is due to the combination of carbon and hydrogen of the candle with the oxygen of the air.

(IV) Some interesting experiments with a candle:—

(a) Take a candle and fix it in the bottom of a jar whose mouth is uncovered. Pour water inside the jar till it is half filled and add baking soda or sodium bicarbonate to it. Light the candle. Pour vinegar to the solution of sodium bicarbonate in the jar. Carbon dioxide will be evolved. Observe what happens to the flame of the burning candle. It will go out. Carbon dioxide will form a covering round the flame of the candle and will cut off the supply of oxygen of the air from reaching the flame. The flame will, therefore, be smothered.

(b) Take a dish and pour water in it. Place a candle on a block of wood and light it. Place the block of wood in the dish, Cover the candle with a bottle having a wide mouth or a gas jar and observe what happens. The water will rush inside the bottle. Can you explain the cause of it ?

(c) Light a candle and put a spiral of copper in its flame. Notice what happens. The flame is extinguished. Can you explain the cause of it ?

A substance must be heated to a certain temperature before it can burn. The lowest temperature at which a substance begins to burn is known as *ignition temperature*. The spiral of copper

absorbs heat from the flame and cools it. As the temperature falls below the ignition point, the flame goes out.

Can you suggest some methods by which you can put out fire:—

(i) Cut off the supply of oxygen of the air from reaching the flame which will be smothered.

Try the following experiment to test this statement:—

Soak a piece of cloth in kerosine oil and put it in a tub and set fire to it. Take a flit sprayer and put in it carbon tetrachloride. Spray this liquid round the burning substance and notice what happens. Carbon tetrachloride will vaporise and form a mantle round the flame and cut off the supply of oxygen of the air to it. The result will be that the flame will be extinguished. This fire can also be put off by sprinkling sand on it. Such fires cannot be put out by water.

(ii) Cool the burning object. When water is poured on the object on fire, its temperature falls below ignition point. Moreover, water vapours form a covering round the flame and cut off the supply of oxygen to it.

(iii) Remove the cause of fire. In case fire is due to electricity, cut off the main supply of electricity to the building.

(V) How to make a candle:—

Melt the following substances together in a vessel and stir the mixture. Pour it into vertical moulds having wicks suspended in them.

Paraffine wax	... ...	15 oz.
Bees wax	... ...	1 oz.
Stearic acid	... ...	9 oz.

(10) Preparation of some useful articles:—

Try to prepare the following articles whose recipes are given below:—

(1) Mosquito oil.

Citronella oil	... ...	2 oz.
Castor oil	... ...	1 oz.
Spirits of camphor	... ...	4 oz.

Take a bottle and shake the above mixture in it and you will get mosquito oil. This oil can be rubbed on the body for repelling the mosquitoes.

(2) *Fly paper.*

Rosin	... ...	16 oz.
Rosin oil	... ...	10 oz.
Castor oil	... ...	4 oz.

Heat the above in an enamelled pot until the whole of rosin has dissolved. Pour it while hot on a stiff paper.

(3) *Tooth powder.*

Precipitated chalk	... ...	280 gr.
Soap	... ...	25 gr.
Sugar	... ...	45 gr.
Magnesium carbonate	... ...	120 gr.
Sodium perborate	... ...	27 gr.
Winter green oil	... ...	4 c. c.
Cinnamon oil	... ...	1 c. c.
Menthol	... ...	½ gr.

Rub winter green oil, cinnamon oil, menthol and sugar together in a pestle and mortar. Add to it sodium perborate and soap and then precipitated chalk and then magnesium carbonate. Sift the mixture through a sieve and bottle it.

(4) *Lemon squash.*

Take a vessel and put in it lemon juice (½ quart) and 2 lbs. of sugar. Put this vessel in another vessel containing hot water till the sugar is dissolved. Keep this squash in bottle. Whenever you want to use it, pour it in a glass and add water to it and enjoy the drink.

(5) *Earache oil.*

Almond oil	... ...	½ oz.
Glycerine	... ...	½ oz.

Keep it in a bottle.

(6) *Tooth ache remedy.*

Phenol	... ...	1.6 gr.
Cinnamon oil	... ...	.88 gr.
Methyl salicylate	... ...	2.5 c. c.

This should be applied to the gums.

(7) *Invisible ink.*

Acetone	... ...	175 c. c.
Caustic potash	... ...	½ gr.
Phenolphthalein	... ...	2 gr.
Water	....	370 c. c.

Mix and stir well these ingredients. You will get invisible ink. Write on a paper with this ink and then put it in ammonia. The writing will become visible.

(8) *Loosening of glass stoppers.*

(a) Allow a few drops of glycerine to soak down the inside edges of the glass stopper which is stuck in the neck of a bottle.

(b) Heat the neck of the bottle so that it expands. The stopper will be loosened. Pull it out.

(9) *Blue black ink.*

Stir the following ingredients in a vessel until dissolved and ink will be ready:—

Napthol blue black	... ...	½ oz.
Gum arabic	... ...	¼ oz.
Carbolic acid	... ...	⅛ oz.
water	... ...	½ gallon.

(10) *Try to prepare shoe polish.*

The recipes are given in the portion on Chemistry for senior members of the club.

(11) *Preservation of different kinds of food by:—*

(a) *Drying in the sun*, as in the case of:

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(i) Badi.

(ii) Papad.

(iii) Dried fruits and vegetables.

(b) *Adding excessive salt*, as in the case of fish.

(c) *Adding excessive sugar*, as in the case of:—

(i) Morabba.

(ii) Petha.

(iii) Jam and Jelley.

(iv) Sweet Chutney.

(d) *Adding vinegar*.

(e) *Adding oil*.

(f) *Adding spices*.

Try to preserve vegetables, fruits and other kinds of food stuff when they can be had in plenty. Experiment on preservation of fruits and vegetables hitherto not in vogue.

(12) *Dyeing cotton and silk materials.*

Try to learn from some book how to dye cotton and silk materials, and try these experiments yourselves.

CHAPTER II

(PART III)

PROJECTS IN PHYSICS.

(For Junior members.)

Heat

1. Melting and Freezing (Regelation).

(a) Take a block of ice and support it on two blocks of wood. Place a wire over it and attach heavy weights like bricks to its ends. The wire will be able to cut its way through ice without breaking it into two pieces.

Can you explain what happens to ice which is below and above the wire ?

N. B. The pressure causes the ice below the wire to melt. The wire sinks in water which freezes again since it is released from pressure. This process continues till the wire is able to cut its way through the block without breakiug it into parts.

Press two pieces of ice together, and these will be joined together.

Can you explain why the blocks are joined together ? Why are snow balls made by pressing the snow between the hands ?

(b) Expansion of water on freezing.

Take a cast iron bomb provided with a hole which can be closed with a screw plug. Fill the bomb with cold water and close the hole with the screw plug. Put it in a vessel containing a freezing mixture of ice and salt. The water in the bomb will freeze and will expand, and the bomb will break.

Can you explain why the bomb explodes ?

Can you explain why the water pipe bursts on a cold day in a place like Simla ?

Repeat experiment (b) with a test tube.

Note: (i) Your observations.

(ii) Your conclusion.

N. B. In general a liquid contracts on freezing, but water expands on freezing when it is cooled below 4°c.

2. Boiling point of a liquid depends upon pressure.

Take a round-bottomed flask, and boil water in it. When steam issues from it, remove the burner and cork the flask tightly, and fit a thermometer in it. Support the flask in an inverted position on a tripod stand. Pour a little of cold water on the bottom of flask ; you will observe that the water in the flask will begin to boil again. This may be repeated a number of times. The temperature may be below 100°C, and yet the water will be found to be boiling.

Can you explain why it is difficult to cook an egg on the top of a mountain ?

N. B. The cold water poured on the flask causes some of the steam to condense in the upper part of the flask, and therefore, the pressure on the surface of water decreases, and it causes the lowering of its boiling point.

3. Determination of Boiling Point.

Boiling point of water:—

Take a test tube and fit it with a cork. Bore two holes in the cork. Fit a thermometer in one of the holes and a glass tube bent at right angles in the other. Boil water in the test tube. The thermometer should not be immersed in water, but should remain in steam. Note the temperature when it becomes constant, and that will be the boiling point of water.

(i) Why should the thermometer be not immersed in water?

(ii) If you go to hills during summer, try to find the boiling point of water there, and keep a record of it in your note book.

(iii) Why is the boiling point of a liquid lower on hills than on plains ?

(iv) Try to find the boiling points of :—

(a) Common salt solution.

(b) Magnesium sulphate solution.

(c) Sugar solution.

(d) Mustard oil and Coconut oil.

Compare the boiling point of water with that of common salt solution.

4. Convection Currents.

(a). Make a box of wood with a glass front. Cut two holes in the upper part of the box and fit them with chimneys. Put a lighted candle under one chimney. Now convection currents will be set up. Bring a smouldering piece of paper near the open end of one chimney, smoke will be found to be going in, and when it is brought near the open end of the other chimney, smoke will be seen to be going out.

What is your conclusion from this experiment ?

N. B. The air near about the candle expands on heating, and increases in volume and decreases in density. It is, therefore, pushed out by the surrounding air which is heavier.

(b) Take a tall cylinder and divide it into two compartments by means of a cardboard or a sheet of metal which is kept a little above the bottom of the jar. Place a lighted candle in the jar with the help of a wire. The candle will continue to burn.

(i) With the help of a smouldering paper try to show the passage of cold air going in.

(ii) Remove the cardboard and observe what happens. (The candle will be extinguished.)

I. Why should you keep the ventilators of a room open ?

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II. Why should the ventilators be higher up on the walls and windows lower down ?

(*c*) *Ventilation box.*

Make a box with holes at its top and bottom. Light candles inside the box. Close the holes at the top of the box, and the candles will be extinguished. Why ?

5. Unequal expansion of different metals on heating.

Take a piece of wood and fix to it a compound bar A made of brass and iron, the more expansible metal brass being on the outside. Fasten to the same piece of wood another metallic bar B, with a metallic wire P soldered to it. Connect a bell and a battery to the bars, as shown in fig. 11. Heat the bar A, it will bend and will come in contact with P. The bell will begin to ring. In the absence of the bell, use a torch bulb. What conclusion do you draw from this experiment ? This arrangement can be used as a fire-alarm.

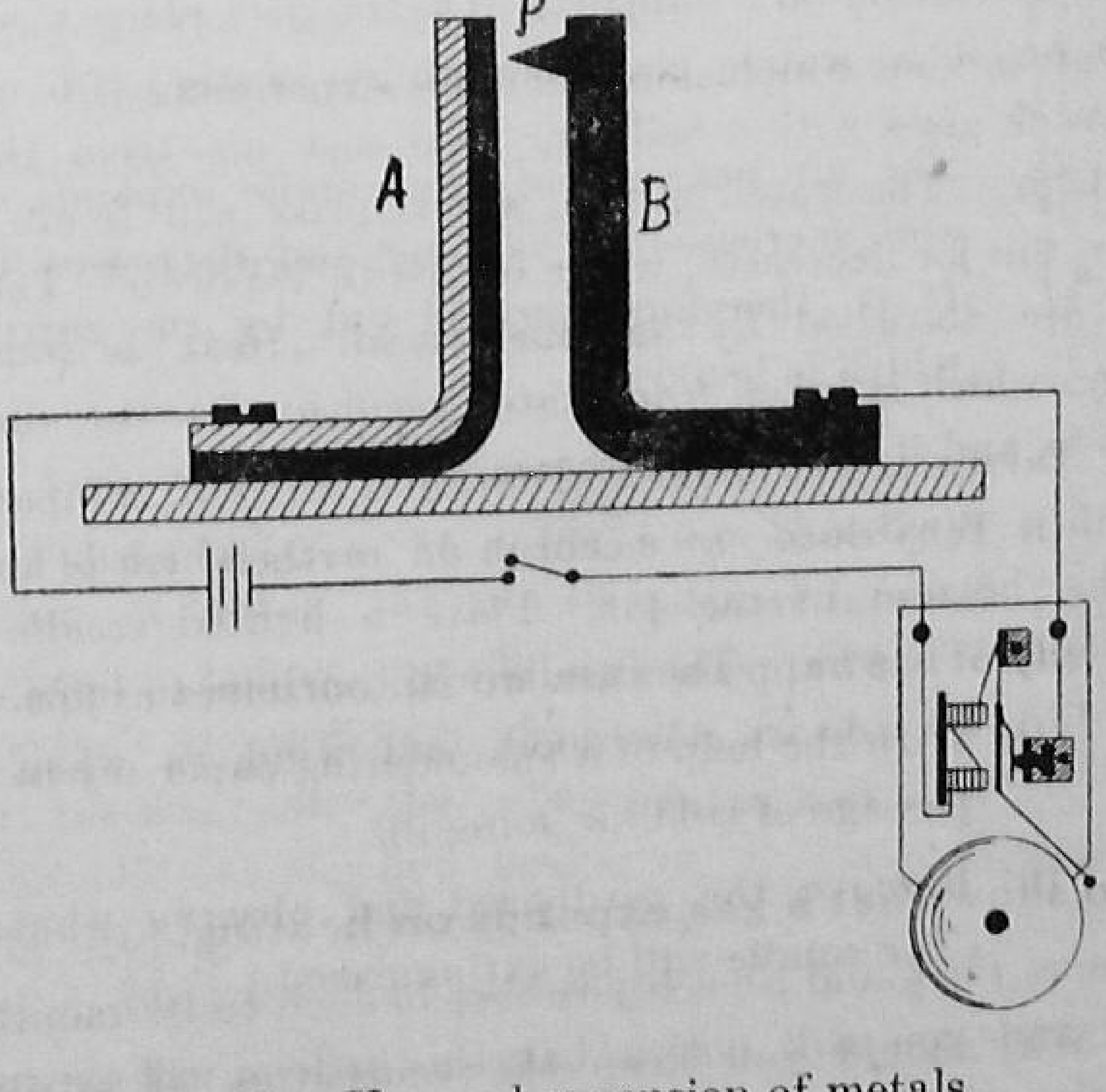


Fig. 11. Unequal expension of metals.

N. B. When the compound bar is heated, brass expands more than iron, and it curves inwards, as brass is on the outside of the bar. Metals expand unequally when heated through the same temperature.

6 (I). Cooling due to evaporation.

(a) Take a block of wood and pour a few drops of cold water on it. Place a thin watch glass containing ether on this thin layer of water. Through a glass tube, blow air in the watch glass. Ether will begin to evaporate. After a few minutes, the water will freeze, and the watch glass will be frozen to the wooden block. What will you conclude from this ?

N. B. Heat is required for the evaporation of a liquid. If it is not supplied from outside, it is taken from the liquid itself. Hence the temperature of the liquid and anything near it will drop.

(b) *If a vacuum pump be available, the same experiment can be tried in the following way :—*

On the plate of the vacuum pump place a dish containing sulphuric acid resting on a support. On the dish place a wire gauze, and place on it a watch glass containing water. Cover the dish and the watch glass with a bell jar. Exhaust air from the interior of the bell jar. The water in the watch glass will freeze. As the pressure in the jar decreases, water begins to vaporise. The vapours of water are absorbed by sulphuric acid. Heat is required for evaporation which is taken from water resulting in the drop of its temperature, and it, therefore, freezes.

(i) Why does water cool in an earthen vessel and not in a metal vessel ?

(ii) What happens when we fan ourselves in hot weather ?

(iii) Why do we close doors and windows when we give bath to a patient ?

6 (II). To show that a gas expands on heating.

Take a flask and tie a toy rubber balloon to its mouth. Heat the flask, and you will notice that the balloon will expand due to the expansion of air in the flask.

6 (III). Suffocation of Candles.

Take a wire and fasten three or four candles to it. Light them and lower them in a tall cylinder and cover its mouth with a disc. At first the topmost candle will go out and then the next one and so on. Carbon dioxide is formed due to the burning of candles, and being heated the gas collects at the top of the jar, thereby extinguishing first the topmost candle and then the next one and so on.

7. To show that water is a poor conductor of heat.

Take a funnel and arrange to pass through its stem the tube of an air thermoscope. Add water to the funnel and place a thin layer of kerosine oil on its top, as shown in fig. 12. Set fire to the oil and you will notice no change in the height of liquid in the thermometer tube. Water in the funnel does not conduct heat from the burning oil to the bulb of the air thermoscope.

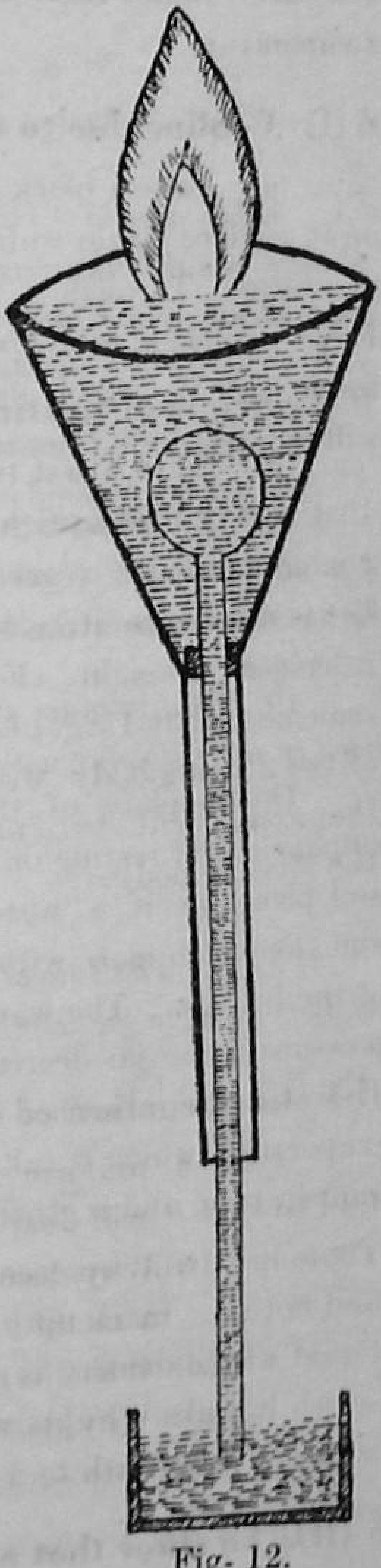


Fig. 12.

8. Principle of Archimedes.

For proving the principle of Archimedes, the apparatus needed are a spring balance, a hollow brass cylinder with an exactly fitting solid cylinder, a pipette, and a beaker of water. From a spring balance suspend a hollow metallic cylinder, and attach the solid cylinder to it. Take the reading on the balance. Immerse the solid cylinder in a beaker of water. The reading on the balance will become less. Why? The solid cylinder has suffered a loss in weight. Add water to the hollow cylinder with a pipette. The original

reading on the balance is again obtained. The loss of weight suffered by the solid cylinder is equal to the weight of liquid in the hollow cylinder. The liquid in the upper cylinder has the same volume and, therefore, the same weight as the liquid displaced by the solid cylinder.

What conclusion do you draw from this ?

When a solid is immersed in a liquid, it suffers a loss in weight which is equal to the weight of the liquid displaced by it. This is the principle of Archimedes.

9. Principle of floating bodies.

(a) Take a test tube and put some leadshots or sand in it so that it may float upright in a liquid. Weigh the test tube and its contents. Take a graduated jar containing water, and immerse the test tube in it. Measure the volume of displaced water and calculate its weight. For calculating the weight of displaced water, remember that 1 c.c. of water weighs 1 gram. Compare the weight of the floating body with the weight of displaced liquid. Repeat the experiment two or three times by varying the weight of the floating body.

N. B. The law of floatation states that the weight of a floating body is equal to the weight of the liquid displaced by its immersed portion.

(b) Construction of a hydrometer.

Take a uniform wooden rod, and load it at one end with lead so that it will float upright. Mark off equal lengths on the rod. These lines will represent equal volumes. Float the rod in water and note the mark upto which it sinks in it. Next float it in the liquid whose density is to be determined, and note the mark upto which it sinks. Suppose the rod is immersed to a mark h cms., in water of density d, and to a mark h_1 cms., in a liquid of density d_1.

$$h \times d = h_1 \times d_1 = \text{weight of rod.}$$

$$\therefore d_1 = \frac{h \times d}{h_1}$$

$$\text{or} \quad \frac{d_1}{d} = \frac{h}{h_1} .$$

$$\text{or specific gravity of liquid} = \frac{h}{h_1} .$$

By this method determine the density of milk, and compare it with the density of pure milk as given in the tables of densities.

10. Atmospheric Pressure.

(a) Take a cylinder and fill it completely with water. Place a disc made of cardboard over the mouth of the cylinder and invert it. The cardboard disc will not fall down. What is your conclusion ?

Conclusion: It is pressed upward by the pressure of the atmosphere. The disc remains in position, however, the cylinder may be turned. Air exerts pressure in all directions.

(b) Take a can made of thin tin plate. Add some water to it. Boil it and when steam begins to issue from its mouth, remove it from the burner and cork it tightly. Allow the can to cool by pouring cold water over it. The steam in it will condense and a partial vacuum will be created inside it.

Note what happens to the tin.

N. B. The pressure of the air outside the can will crush it.

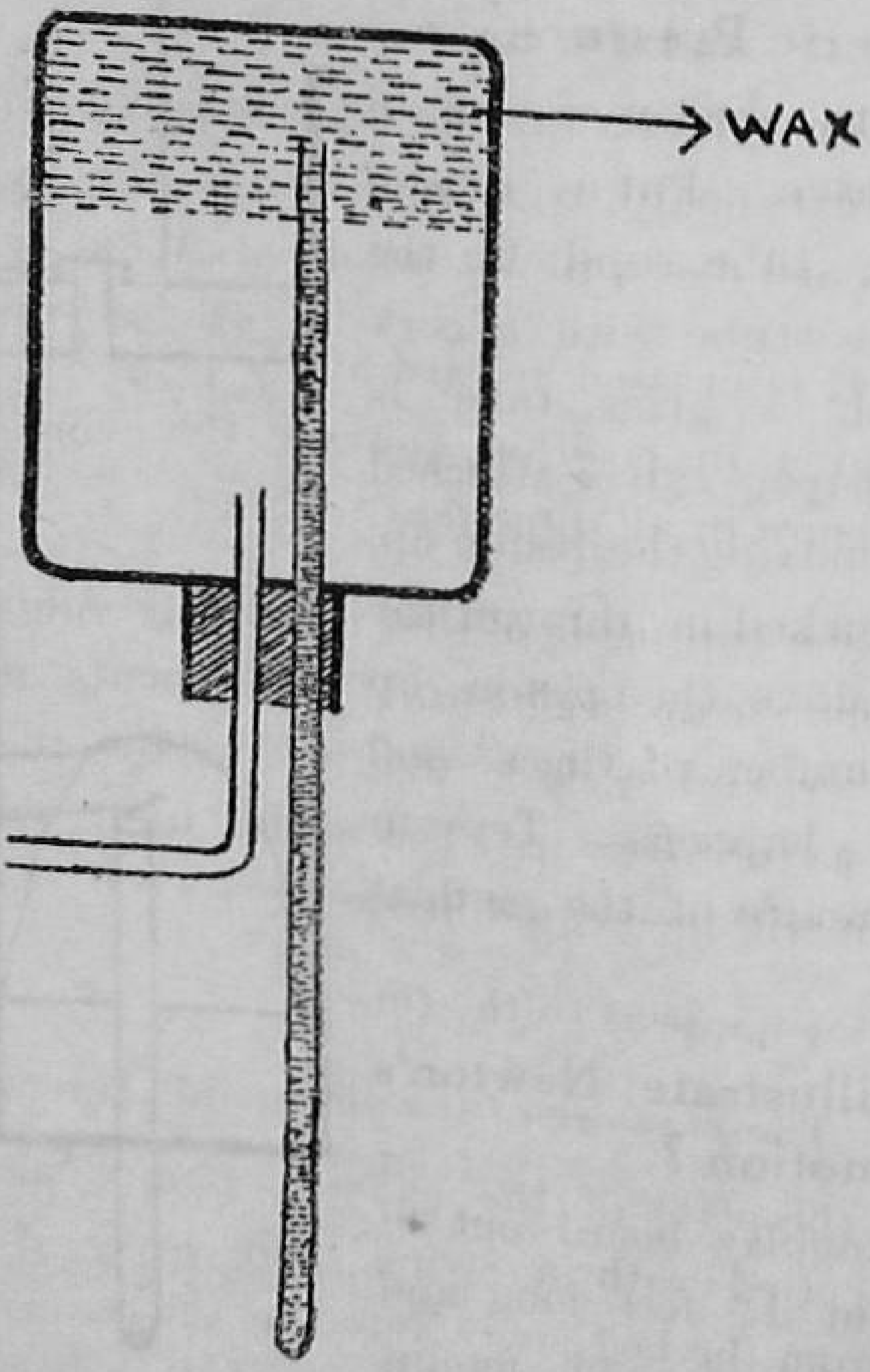
(c) On the plate of the exhaust pump, place a toy-balloon whose neck is tied with a string, and cover it with a bell jar. Exhaust air from the bell jar. Note the effect on the balloon. It will swell up and may even burst. Introduce air in the bell jar. and the balloon will collapse.

N. B. Can you explain why are we not crushed to pieces when there is so much pressure exerted on us by the atmosphere ?

11. To set up a mercury barometer, and to prove that the height of mercury column depends upon pressure.

Take a barometric tube which is closed at one end, and fill it with mercury. Take a bottle and add melted wax to it and let it harden. Fit the bottle with a rubber cork provided with two holes.

Allow the barometric tube to pass through one hole till the open end of tube is a little pressed below wax. Invert the bottle and add mercury to it through the other hole in the cork, and pull the barometric tube out of wax. A Torricellian vacuum is produced in the tube and the height of mercury column in the tube above the surface of mercury in the bottle is a measure of barometric pressure.



Fig, 13. Barometric tube in an inverted position

Pass a delivery tube through the other hole in the cork and let the end of this tube remain above the surface of mercury in the bottle, as shown in fig. 13. Attach a rubber tube to the delivery tube, and blow air through it and the mercury column will rise in the barometric tube due to increase in pressure. Suck air out of the bottle by means of the delivery tube, and the column of mercury will fall.

12. To illustrate the principle of a vacuum cleaner.

Take a strong glass tube about 7 or 8 inches in length and an inch in width. Fit it with a piston which is a rubber cork provided with a handle. Make a hole in the cork and pass a small glass tube through it and fit its top with paper with shellac so as to serve as a valve. Put a muslin bag inside the tube, and fit the lower end of the tube with a cork through which a glass tube is passed with a paper valve attached to its top. By moving the piston up, dust will be sucked in through the lower tube. Move the piston up and down a number of times, and observe what happens. Try to explain the principle of the method outlined above.

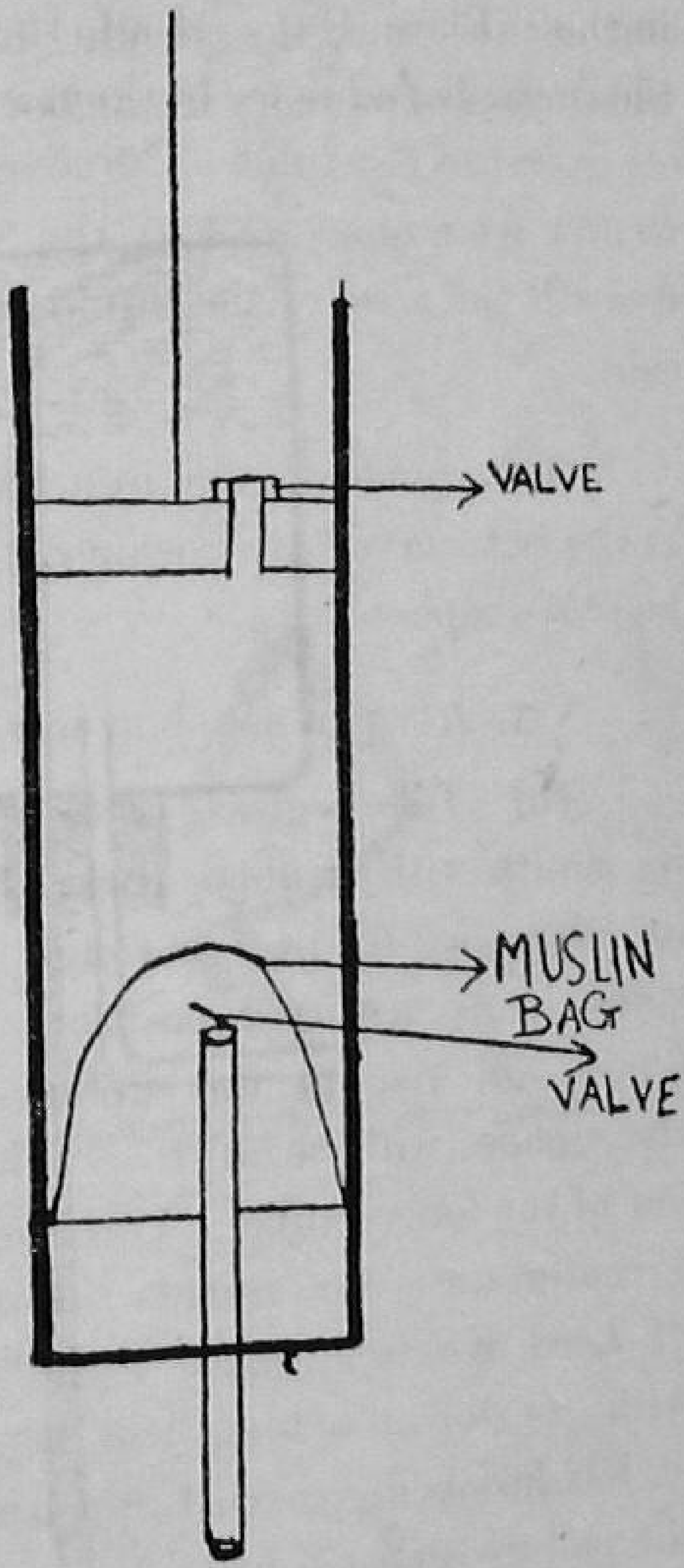


Fig. 14.
Principle of vacuum cleaner.

13. How to illustrate Newton's third law of motion ?

Cut a rectangular board out of ply wood about $1\frac{1}{2}$ feet long and 6 or 7 inches broad, and mount it on four wheels. Fix another board perpendicular to the first one somewhere near its middle. Make a hole in the centre of the second board. Pass the nozzle of an inflated foot-ball bladder through the hole, and on releasing the air from it, the cart so constructed will move in a direction opposite to that of the issuing air. Explain the cause of it.

14. Siphon.

(a) Take a glass tube and bend it twice at right angles making one limb shorter than the other. The glass tube so prepared is a

siphon. It can be used to transfer liquid from one vessel to the other, especially where the sediment is not to be disturbed. Fill your siphon with the given liquid and close its open ends with your fingers. Place the end of the shorter tube in the vessel from where the liquid is to be removed, and place a beaker below the other end of the tube. Remove the fingers. The liquid will begin to flow from one vessel to the other. The liquid will continue to flow till the level of the liquid falls below the mouth of the shorter tube.

Take muddy water in a beaker and let the mud settle down at the bottom of the beaker. Remove the clear liquid with the help of a siphon.

N. B. Can a siphon work in vacuum ?

(b) Take a glass bottle whose bottom has been cut and fit its mouth with a rubber cork. Fit inside the bottle a siphon allowing its longer leg to pass through a hole in the cork, and fix it in a stand in an inverted position. If you pour water in the cup, the liquid will rise in the siphon, and when it will reach its bend, the siphon will begin to work and the liquid will begin to flow out of the longer tube. You may make use of the above principle to entertain your friends. For illustrating the story of the birth of Lord Krishna, place a hollow wooden case round the siphon with its top touching the bend of the siphon. Make the picture of Krishna being carried in a basket by his father Vasudeva, and fix the picture on a tin plate. Arrange the tin plate inside the cup so that the feet of Krishna touch the top of the case surrounding the siphon. Pour water in the cup, and you will find that when the level of water will reach the bend of the siphon, the latter will begin to work. Thus it will appear as if the river Jumna in floods begins to ebb, while Vasudeva crosses it carrying the baby in the basket, until it touches the feet of the baby.

15. Centre of Gravity.

(a) Take a cork and try to balance it on a nail point. It will be difficult to balance it. Stick two pen holders in the cork and it will be balanced. The centre of gravity of the whole is very much

lowered, and is brought near the point of support. You can try the experiment with forks instead of pen holders.

(b) Cut a figure out of wood or thick card-board, as shown in fig. 15, and try to support it on a wire stretched between two clamp stands. The toy figure will not fall, even though it may be jerked. The curved wire with the metal balls attached to its ends helps to keep the vertical line through the centre of gravity of the body on the wire.

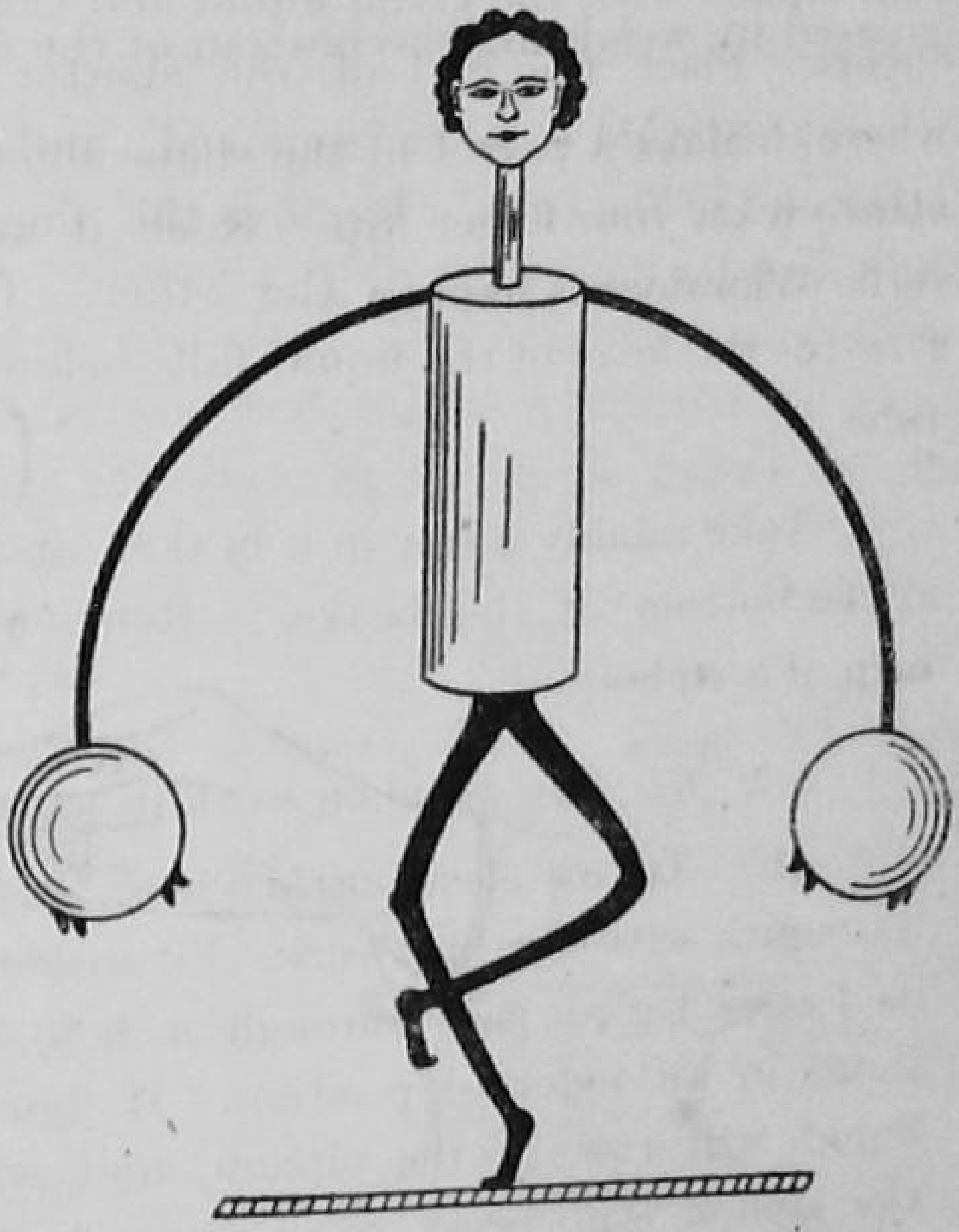


Fig. 15. Centre of grairty expt.

(c) Construct a toy horse out of wood or thick card board, as shown in fig. 16, and support it on its hind legs on the edge of a table; the toy horse will not topple over, when moved. The vertical line through the centre of gravity falls within the base. Mark the position of curved wire with a metal ball attached to it in the diagram.

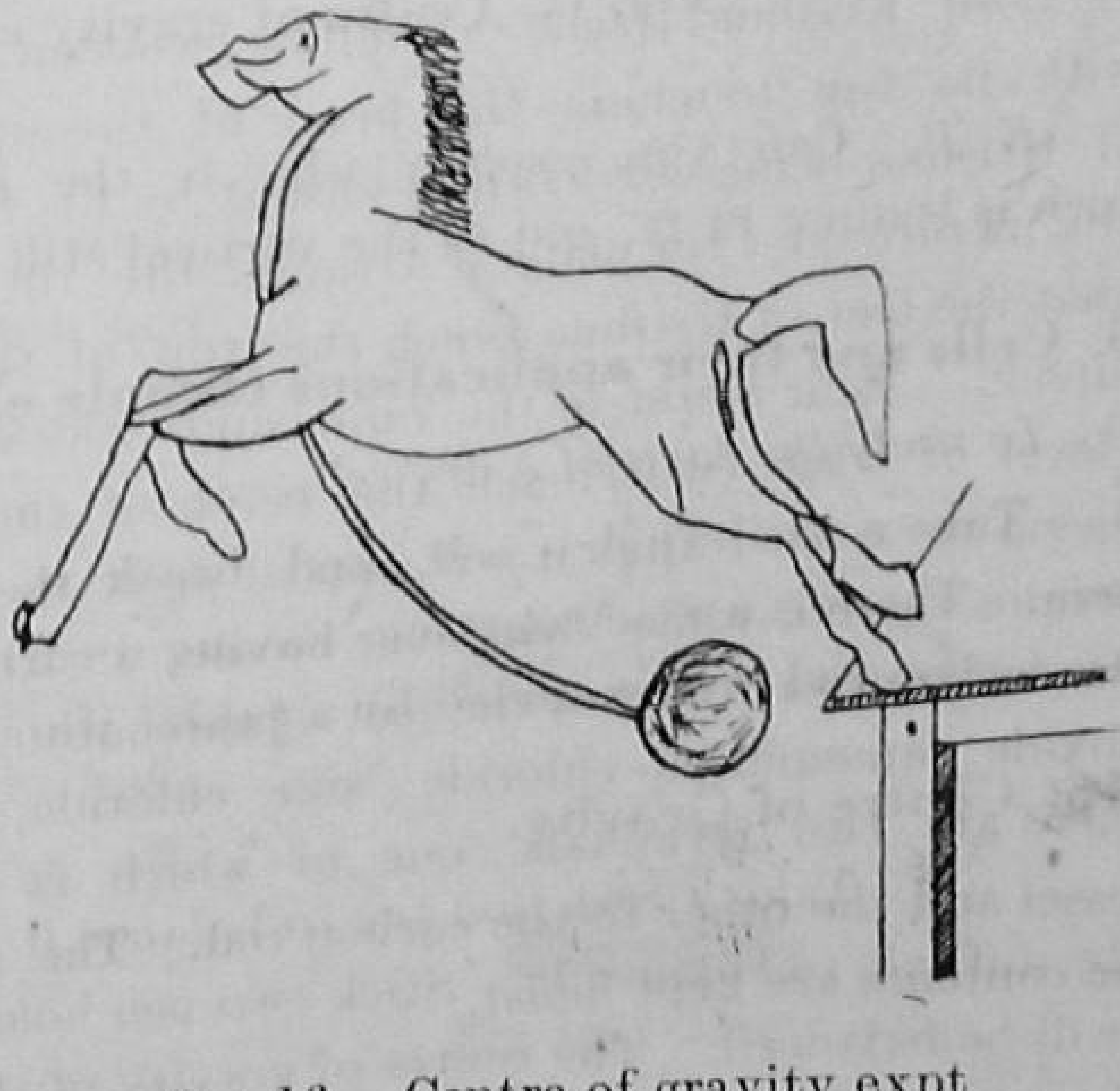
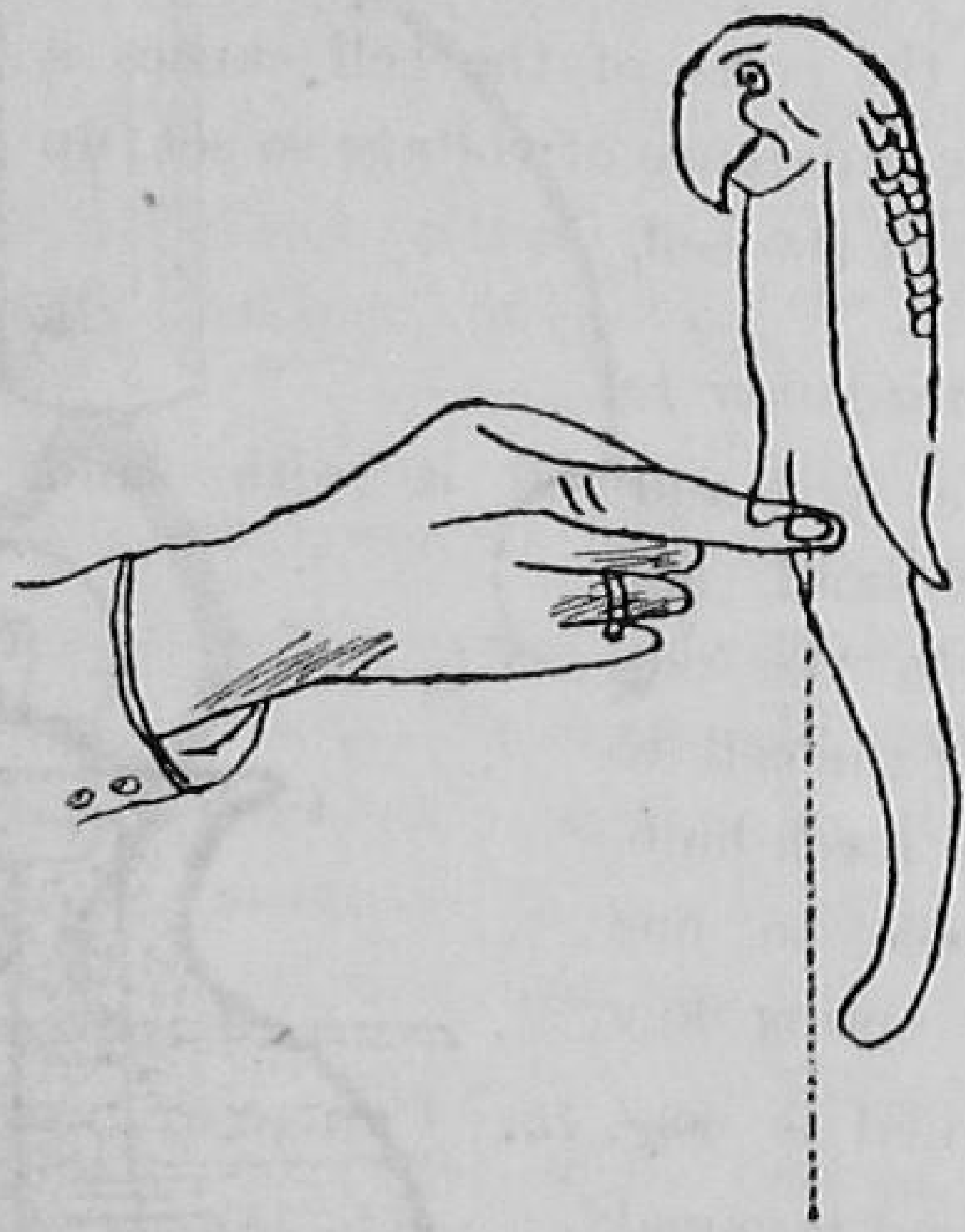


Fig. 16. Centre of gravity expt

(d) Make a toy wrestler by weighting a cup with mud or lead shots and wrapping a paper round it so as to form a cone. Try to knock it down. Your attempt will be in vain. The stability has been increased by weighting the bottom of the figure.

(e) Make a parrot of the shape shown in fig. 17., and try to balance it on your finger tip. Rock it and it will not be toppled over. Why does it happen so ?



Fig, 17. Centre of gravity expt.

N. B. Can you explain why is the leaning tower at Pisa which is leaning 14 ft., out of the vertical still in stable equilibrium ?

16. Cells and their applications (simple electrical circuits).

(*a*) *To study the parts of a dry cell :—*

Take a used up dry cell, and break it into parts and study them. There is a zinc container having a carbon rod in its centre. The carbon rod is surrounded by a paste which contains manganese dioxide, ammonium chloride, zinc chloride, sawdust and water. There are two terminals, one of which is connected to the zinc vessel and the other to the carbon rod. The cell works so long as the contents are kept moist.

(b) To construct a dry Cell.

Take a beaker and put in it a rod of zinc. In the middle of the beaker place a rod of carbon, and between the two rods, put ammonium chloride, zinc chloride, powdered coke, manganese dioxide and sawdust soaked in water. Attach a terminal to zinc and another to carbon. The cell will begin to work. Connect the poles of the cell to a voltmeter and determine the voltage developed between the poles of the cell. The difference of voltage developed between the poles of the cell causes a current of electricity to flow. The difference of voltage so set up is known as the electromotive force of the cell.

(c) Magic lamp in a flower pot.

Take a flower pot and fill it with sand. Place a torch bulb at the top of sand, and conceal a dry cell in the pot. Connect one pole of the cell to one terminal of the torch bulb, and its other pole to one terminal of the spring key whose other terminal is connected to the second terminal of the electric bulb. Place the spring key on the ground and work it with your foot. Excepting the bulb and the flower pot nothing else should be visible. Make and break the circuit with your foot, and to the amazement of the visitors, the magic bulb will be lighted on and off, when a command is given to it.

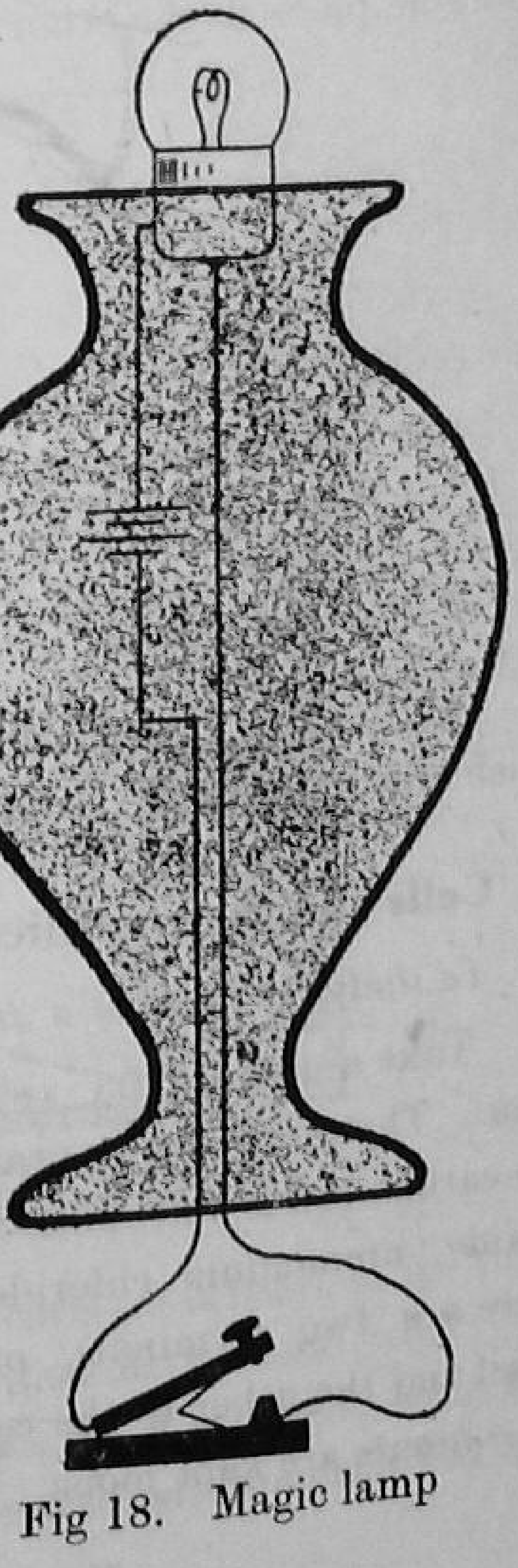


Fig 18. Magic lamp

(d) *Night watch.*

Make a box of wood, and fix a lamp holder to the top of the box. Place a dry cell inside the box. Connect the lamp-holder, the cell and a bed switch in series. Fix a hook to the lid of the box and suspend a watch from it. Press the bed switch. The circuit will be completed, and the lamp will be lighted and you will be able to note the time. Put off the light by the bed switch after noting time.

(e) *To make a portable electric lamp.*

Make a small wooden box, and attach a switch to its top and a torch bulb to its front surface. Place a dry cell inside the box. Connect the cell, the switch and the lamp in series. The box should be provided with a handle so that it can be easily carried from one place to the other.

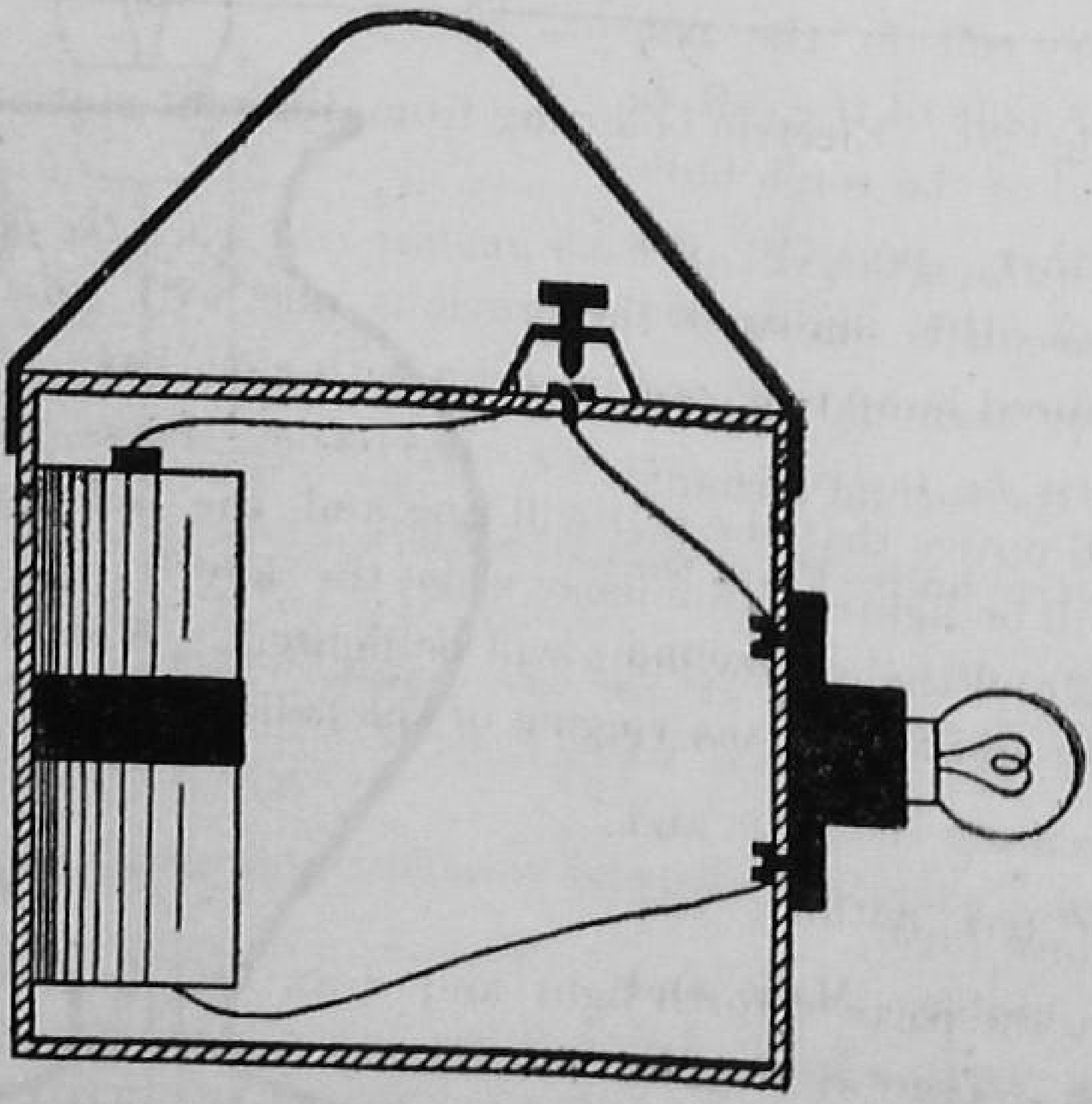


Fig. 19. Portable electric lamp.

(f) *To ring a bell from different stations.*

Take an electric bell, and connect it to a battery and three separate bell pushes K_1 K_2 and K_3, Making a separate circuit with each bell push and the battery and the bell as shown in Fig. 20.

Press the key K_1 and the bell will ring. Similarly the bell will ring on pressing K_2 or K_3. Make your own switches in the workshop.

Why does the bell ring when one of the bell pushes is pressed ?

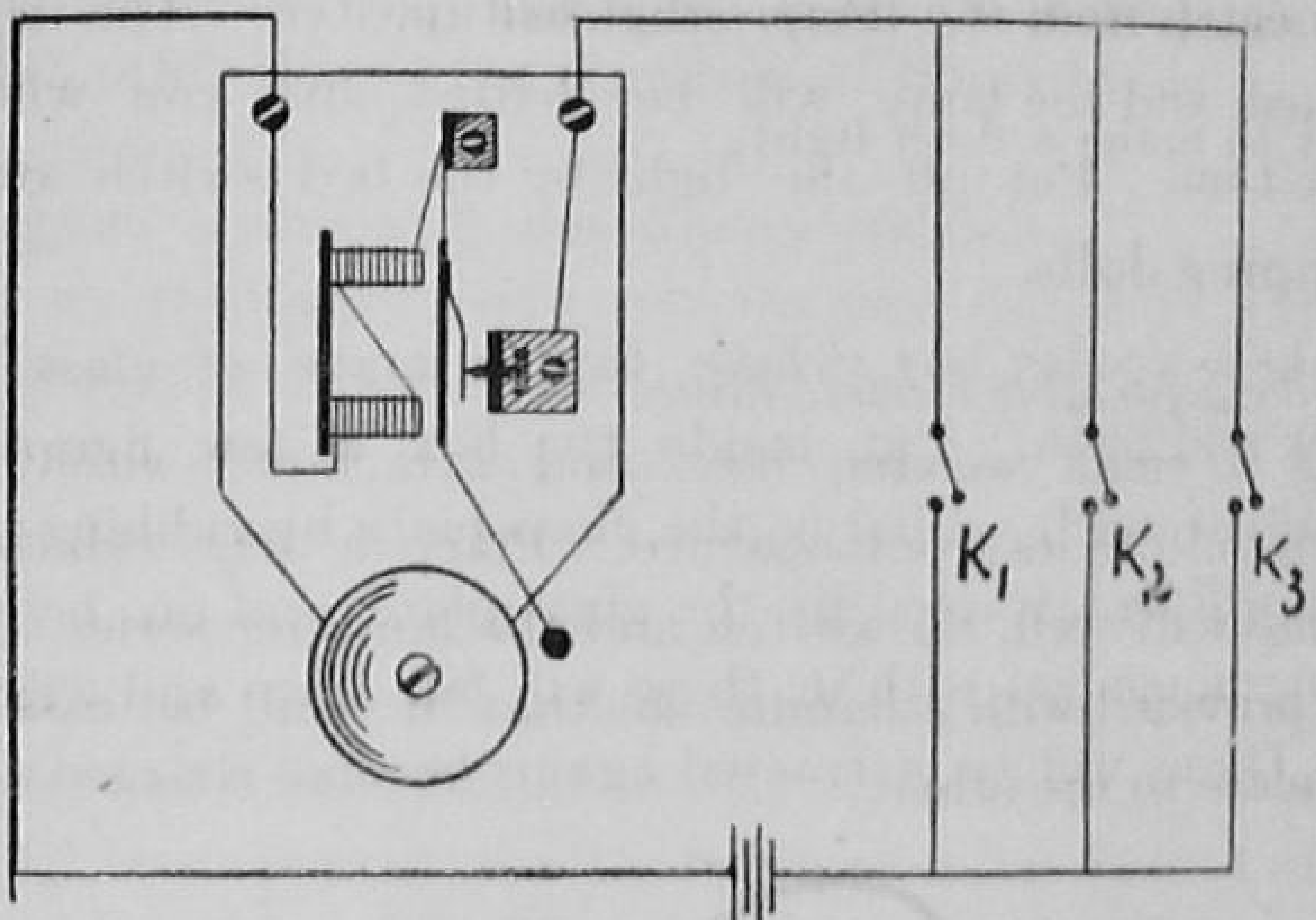


Fig. 20. Electric bell rung from different stations.

(g) *To distinguish one call from another call when the bell rings.*

This circuit is similar to the previous one with this difference that a coloured lamp is placed in series with each key. *The number of cells must be increased for this experiment.* Press the key K_1, and you will notice that the bell will ring and the red lamp placed in circuit will be lighted. Similarly when the key K_2 is pressed, the bell wil ring and the yellow lamp will be lighted. When the key K_3 is pressed, in addition to the ringing of the bell, the green lamp will glow.

(h) *Flash Light.*

Study the parts of torch light and draw its diagram in your record book. There is a small electric lamp inside the metal case. The bulb is at the centre of a metal bowl and the switch is at one side of the metal case. There are cells inside the case joined in series, and the top one touches the bottom of the lamp, and a spring inside the case at its bottom keeps them pushed up. When the switch is closed, a piece of metal touches the metal bowl and the circuit is closed. Trace the path of the current when the

switch is closed. The positive pole of the battery touches the bottom of the lamp. The current after flowing through the filament of the lamp, the metal bowl, the switch, the metal case, and the spring reaches the negative pole of the battery. Whenever the circuit is completed, the lamp is lighted up.

Try to make a flash light.

17. Jumping dolls.

Make a wooden box whose top is made of glass which can slide back and forth. Put inside the box a few figures made of pith (core of reed). Charge the glass plate by rubbing it with silk. The dolls will be attracted by the glass plate, and on being charged by coming in contact with it, these will fall down and will lose their charge. These will be attracted again, become charged and will fall down.

18. To make an electromagnet.

Take a rod of soft iron, and wind about 25 turns of No. 18 gauge insulated copper wire round it so as to form a coil. Connect a dry cell to the coil through a key. Close the key and the electromagnet will be energised. Bring it near iron filings, and it will pick up these filings. Open the key, and the filings will fall down. Can you explain why the filings fall down ? Is an electromagnet a temporary or a permanent magnet ?

Now bend the rod of soft iron, and wind electric wire on it. Again pass the electric current through the coil, and observe the effect of the electromagnet on a heap of iron filings.

Moreover, bring a nail in contact with one pole of the electromagnet and to it attach another nail, and in this way form a magnetic chain. Can you explain how the magnetic chain is formed ?

19. Magnetism.

(a) Magnetic ducks.

Magnetise two or three razor blades and cut them in different pieces, and you will get so many magnets. Take four or five toy ducks and stick in the beak of each a magnet. Float the

ducks in a vessel containing water. What will you observe; Some of the ducks will move closer to each other, and some of them will be found repelling each other. Can you explain the phenomenon ? The ducks will be drawn closer to each other due to the attraction of opposite poles and some of them will be found repelling each other due to the repulsion of similar poles.

(*b*) *Magnetic toy about Rama, Ravan and Sita.*

Take a cardboard and on its one side draw the picture of Rama and on the other Ravan with his many heads. Support the picture in a metal frame and fit glass on the two pictures. Conceal a small magnet in a metal or wooden base and to it attach the metal frame carrying the pictures. On another cardboard draw the picture of Sita. Conceal another small magnet in another metallic or woodn base and fix the picture of Sita vertically to this base. Make some rocking arrangement for this picture frame of Sita which can even be suspended if so desired. While concealing the magnets in the two metal bases, take care that the opposite poles of the two magnets face each other when Rama's picture is turned towards Sita's, and that similar poles come opposite to each other when Ravan's picture comes opposite to Sita's.

(*c*) *Magnetic field.*

Trace magnetic fields with the help of bar magnets and horse-shoe magnets by using a glass sheet and iron filings.

20 Light.

(*a*) *Lateral inversion.*

Take a plane mirror and place it upright on the surface of a table with the help of supports. Draw the diagram of half of the body of a fish on a paper and place it on the table under the edge of the mirror. You will see the complete body of the fish. Similarly draw a semicircle on a paper and place it in front of the plane mirror, and you will see a complete circle. Letters which have lower halves like upper halves can be used for seeing complete letters. These are B,C,D,E,H,I,K,O, and X.

N. B. This is due to lateral inversion.

(b) Kaleidoscope.

(i) Inclined mirrors are used in the construction of a *Kaleidoscope*. Take three strips of mirrors and enclose them in a tube, so that the mirrors are inclined to each another at angles of 60 degrees. Cover one end of the tube with a disc of cardboard with a hole in its centre to which the eye is applied. Fix a ground glass screen at the other end and a clear glass on the inside of the tube, and put a number of pieces of coloured glass between the two glass discs. Look through the hole you will see a pattern formed by the pieces of coloured glass and and their images in the mirrors. Rotate the tube and you will see that the pattern will change in form since the pieces of glass will fall into fresh positions. This instrument is of help to designers.

(ii) Try to construct an instrument with six mirrors so as to form a hexagon. The mirrors can be inserted in a box whose sides are vertical.

(c) Endless world.

Make a tall wooden box and fix plane mirrors on its four inner walls. Cover the box with a lid provided with an electric lamp. Make a hole in one of the sides of the wooden box and remove silver from the back of the mirror facing the hole. Put coloured flowers on the bottom of the box. Light the lamp and look through the hole. You will be able to see so many images due to multiple reflection.

(d) Multiple images formed by inclined mirrors.

Incline two mirrors to a right angle and place a lighted candle between them and observe the number of images formed. Change the angle between the mirrors to 60 degrees, and again observe the number of images formed. Vary the angle a number of times, and observe the images in each case. You can use a torch bulb in place of the candle.

21. To study the formation of a spectrum by a prism.

(a) Pass a beam of sunlight through a hole in a shutter and place a prism between the hole and the screen. You will get a band of colours on the screen consisting of violet, indigo, blue, green, yellow, orange and red. The violet will be at the top and

the red at the bottom of the band of colours which is known as *Spectrum*. The word "Vibgyor" will remind you of the names of different colours, and their order. But it is not a true word. What is your conclusion about the composition of white light ?

N. B. White light is made up of seven colours. In passing through a prism these differently coloured rays are deviated to different extents, violet being deviated the greatest and red the least.

(b) Take a slit and illuminate it with sunlight and focus the light from the slit by a lens so as to form a sharp image of it on a screen in the absence of a prism. Now place a prism between the lens and the image, the light will be dispersed. The light of each colour will be deviated to a different extent, and, therefore, you will get a spectrum on the screen. Rotate the priom so as to get a sharp spectrum. You can illuminate the slit with light from the filament of an electric lamp for this experiment. Study the difference in the spectra formed in (a) and (b). The spectrum in (b) will be sharper than in (a).

(c) *Coloured disc.*

White light is composed of seven colours. You can put these colours together to make white. Take Newton's coloured disc and mount it on a whirling table. Set the disc rotating fast, and it will look white. It looks white due to "persistence of vision". An impression that falls on the retina of the eye lasts for 1/10th of a second. When the impression of one colour falls on the retina of the eye, it is not removed when another impression falls and due to the blending of all these impressions the disc looks white.

(d) *Colour of objects.*

(i) Throw the spectrum of sunlight formed by a prism on the wall of your room. Move a white flower from one part of spectrum to the other, and observe what happens. In the red part it looks red, in blue it looks blue and in green it looks green and so on. A black body absorbs all the colours and reflects none to the eye. Try your experiment with red and yellow flowers.

(ii) Draw circles on a sheet of paper with coloured crayons. one blue, and one red. Take a cellophane paper or red glass and look at the blue circle through it. The circle will appear black. The blue rays reflected by the circle are absorbed by cellophane or red glass. The circle is reflecting blue rays of light but these are not reaching the eye and so it looks black. Note the colour of white paper around the blue circle. It will appear red.

Look at the red circle through a blue glass or cellophane, the red circle will appear black and the white paper around blue.

(e) *Complimentary colours.*

Two colours which by their union produce white light are known as complimentary colours. Red and green are complimentary colours.

Draw a circle of about 2 inches diameter on a sheet of paper and colour it red. Hold this paper at arm's length with your right hand, and another blank white paper at the same distance from you with your left hand. Stare hard for a few minutes at the red circle and then look at the white paper. Note the change that you observe. The white paper will appear green.

When the eyes are tired by looking at red colour and are turned to white paper, these are no longer able to see red light reflected by the paper. But they see the complimentary colour which is green.

Try the experiment with a blue circle and find the colour complementary to blue.

N. B. Yellow and blue are complimentary colours.

22. Sound.

(a) *Reflection of Sound.*

Take a plane mirror and mount it on a stand and place it upright on a table. Place two metallic tubes inclined to the mirror. Hold the tubes in position by clamp stands. Place a wrist watch inside one of the tubes, and adjust the other tube till you are able

to see the image of the watch in the mirror when looked through the tube. Apply your ear to the end of the receiving tube and you will be able to hear the ticking of the watch. Replace the mirror by a wooden board and then by a metallic plate. You will be able to hear the ticks in each case. This experiment shows that sound is reflected by a mirror, wood or metal.

What is the relation between the angles of incidence and reflection ? (These are equal.)

N. B. 1. What is an echo ?

2. Sometimes echoes are troublesome. How can you cause them to die? (Just hang in the hall curtains and tapestries and the echoes will vanish.)

(*b*) *Refraction of Sound.*

Make a lens for refracting sound by filling a thin india-rubber balloon with carbon dioxide. Place a watch close to the lens, and on the other side, place a funnel to which a rubber tube is attached. Put the rubber tube in the ear. Move the funnel backwards and forwards, and find a point where you will be able to hear the ticking of the watch. Remove the lens and again observe the effect. You will notice that the noise of ticking will be diminished in loudness. Determine the focal length of the lens. Measure the distance of the object (watch) and of the image from the lens where the sound is maximum. Calling these distances u and v respectively, calculate the focal length of the lens from the formula $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$.

(*c*) *Musical Sound.*

To illustrate that pitch of a musical sound depends upon frequency.

This can be illustrated by a simple siren. It is a metal disc provided with rows of equally spaced holes. Mount the disc on a whirling table, and direct a jet of air against the outer row of holes, the regular succession of puffs coming out of the holes will produce a musical sound. Increase the speed of rotation of the disc and observe the effect on the musical tone produced. It will rise in

pitch. Now direct the jet of air against the smaller number of holes, the pitch of the tone will decrease. Place the nozzle of the tube against the row of irregularly spaced holes, you will now get a noise.

What is your conclusion from this experiment?

N. B. A musical sound is produced when the sound waves follow each other in regular succession. Moreover, the pitch of a musical sound depends upon frequency viz. the number of vibrations produced per second.

What are the other chracteristics of a musical sound? These are *intensity (loudness) and quality.*

(*d*) *Resonance.*

(*i*) *Demonstration of the principle of resonance.*

Stretch a rubber tube between two supports and from it suspend two pendulums of equal length. Set one pendulum vibrating. The other pendulum will soon begin to vibrate. The first pendulum will come to a stop, since the energy will pass from first to second through the rubber tube. This can only happen when both the pendulums will have the same length, and, therefore, the same frequency. This phenomenon is known as *resonance.*

N. B. What is resonance ? It is a phenomenon in which one vibrating body is able to transfer energy to the other when both of them have the same frequency.

(*ii*) Take two tuning forks mounted on resonance boxes, and let these be of the same frequency. Set one of the forks vibrating with a wooden mallet, and then quickly stop it, and the other fork will be heard emitting second. The second fork has been set in motion by the sound waves produced by the first fork. Attach a piece of wax to a prong of one of the forks, and find out if resonance can still take place. The forks will no longer respond to each other.

(*iii*) *Resonance Tube.*

Take a tall jar of water and hold a glass tube in it. Raise or lower the tube in the jar of water, and at the same time hold a

vibrating tuning fork over the mouth of the tube. Find a position where sound becomes loudest. At this position the sound of the fork is strengthened by the sound of the air column. It is a case of resonance, since the air column and the fork vibrate with the same frequency.

Measure the length of the vibrating column of air and calculate the velocity of sound in air from the formula: $v=n\times 4l$ where n is the frequency of tuning fork, and l the length of vibrating column of air. This is the velocity of sound at room temperature.

Does velocity of sound depend upon temperature ?

(e) *Presence of a material medium on transmission of sound.*

Suspend an electric bell by means of wire inside a bell jar, and fix the bell jar on the plate of an exhaust pump. Connect a battery and a key to the bell inside the bell jar. Set the bell ringing by closing the circuit. Exhaust air from the interior of bell jar and observe the effect on sound. It will grow fainter and fainter in intensity. Admit air in the bell jar, the intensity of sound will again increase. This shows that a material medium is essential for the transmission of sound.

N. B. Is air necessary for the transmission of light ? Can light pass through vacuum ?

(f) *To prove that sound is transmitted by water.*

Take a tuning fork and fit a rubber cork to its handle. Set the tuning fork vibrating and push the stopper in a beaker containing water. The sound will be transmitted through the water to the table.

(g) *To make a toy-telephone.*

Take two tin cans and join them by a cord which is kept stretched. Speak into one of the cans and its bottom will vibrate. The sound will be conducted along the cord to the other can and its bottom will begin to vibrate. If a person were to apply his ear to this can, he will able to hear what the other person will speak in the other can. The experiment can be tried even with cardboard boxes.

CHAPTER III

PART I

PROJECTS IN BIOLOGY

(For senior members of science clubs)

1. Transpiration.

(a) Place leaves of shepherd's purse or Oleander (Kaver) on a sheet of dry blotting paper, some with their upper and some with their under surfaces directed upwards. Small pieces of dry cobalt-paper (filter papers soaked in 5% cobalt chloride solution and thoroughly dried) may then be laid on each, and the entire series may be covered with a dry sheet of glass to prevent access of damp air. It will be noticed that the papers in contact with under surfaces of the leaves become pink more rapidly than those upon the upper surfaces, thus showing that more water vapour escapes in a given time from the under than from the upper surface. This is due to the fact that the stomata are usually more numerous on the under than on the upper surface.

Experiments to illustrate loss of water by transpiration.

(b) Take a potted plant and cover the soil surfaces with paraffin or other water-proof covering. Place it on scales and weigh it after short intervals. Note your observations and conclusions.

(c) Select a pot of a healthy plant. Cover the soil and pot with silver paper or any other waterproof. Cover the pot and the plant by a bell-jar. Observe it at intervals of half an hour and make note of your observations and conclusions.

(d) Devise an experiment to find the relation between the water absorbed by the roots of a plant and water lost by the plant in the process of transpiration.

(e) Find the rate of transpiration by the help of potometer.

Try to find out the effect of transpiration on plants —

(i) its effect on the temperature of the plant

(ii) its function as an agency for pushing up water from the root to the other top parts of the plant

(iii) its function as an agency for getting rid of excess water absorbed so that nutrition level of plant is maintained.

2 Respiration

(a) Set up the apparatus as shown in fig., 21., and pass a current of air which has been previously deprived of its carbon dioxide by caustic potash solution, through a jar containing green plant.

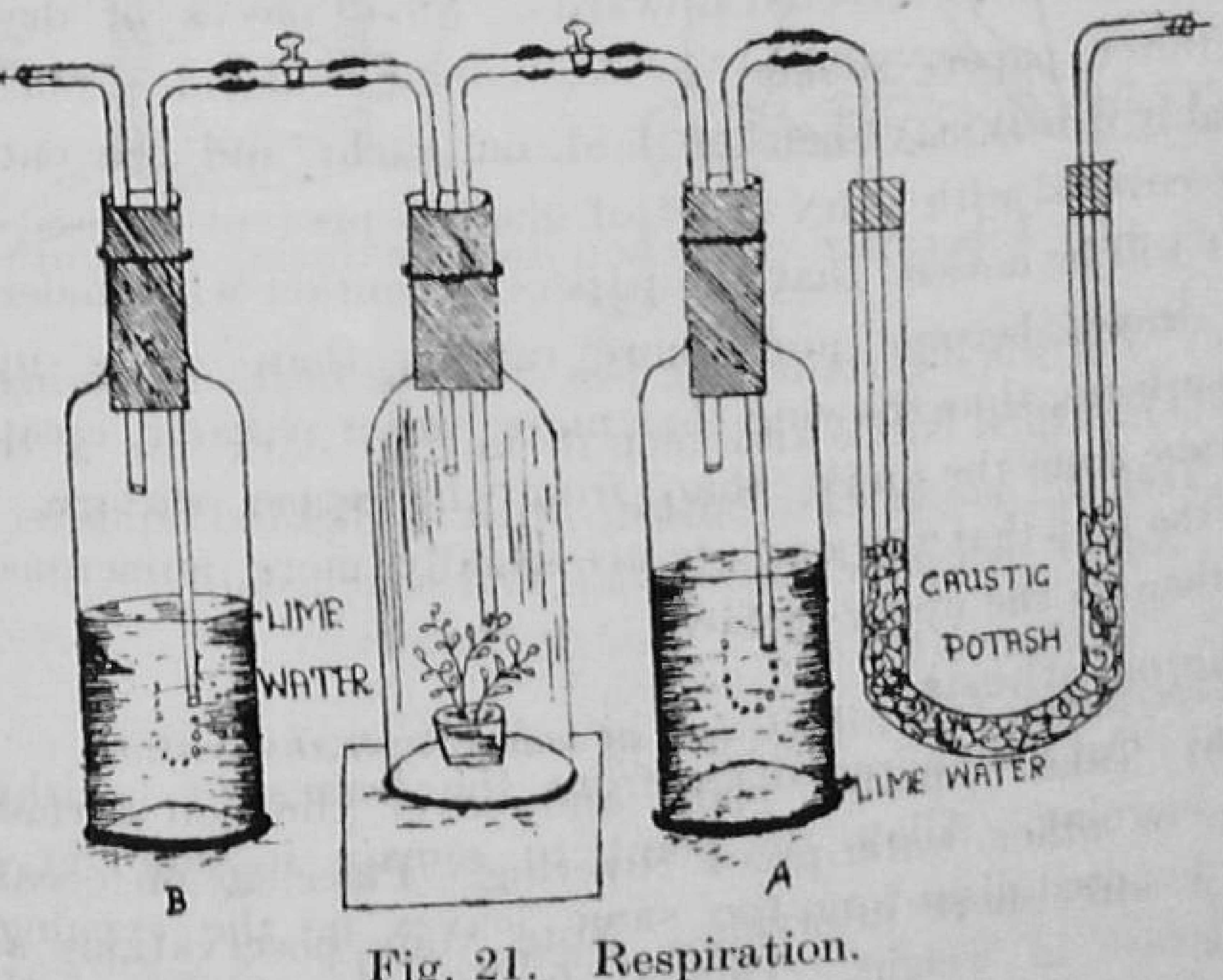


Fig. 21. Respiration.

(i) Observe the lime water contained in bottle A.

(ii) Observe the lime water contained in bottle B.

(iii) Note down your conclusion.

(b) Place some germinating pea seeds in a flask along with pieces of moist blotting paper. Close it with an air tight rubber cork fitted with a glass tube bent twice at right angles as shown in fig. 22. At the inner end, suspend by means of a cotton thread a small bottle containing a concentrated solution of caustic potash.

The free end of the tube dips in water contained in a beaker. Leave the apparatus for a few minutes ; note the level of water column in the tube. Give your conclusion.

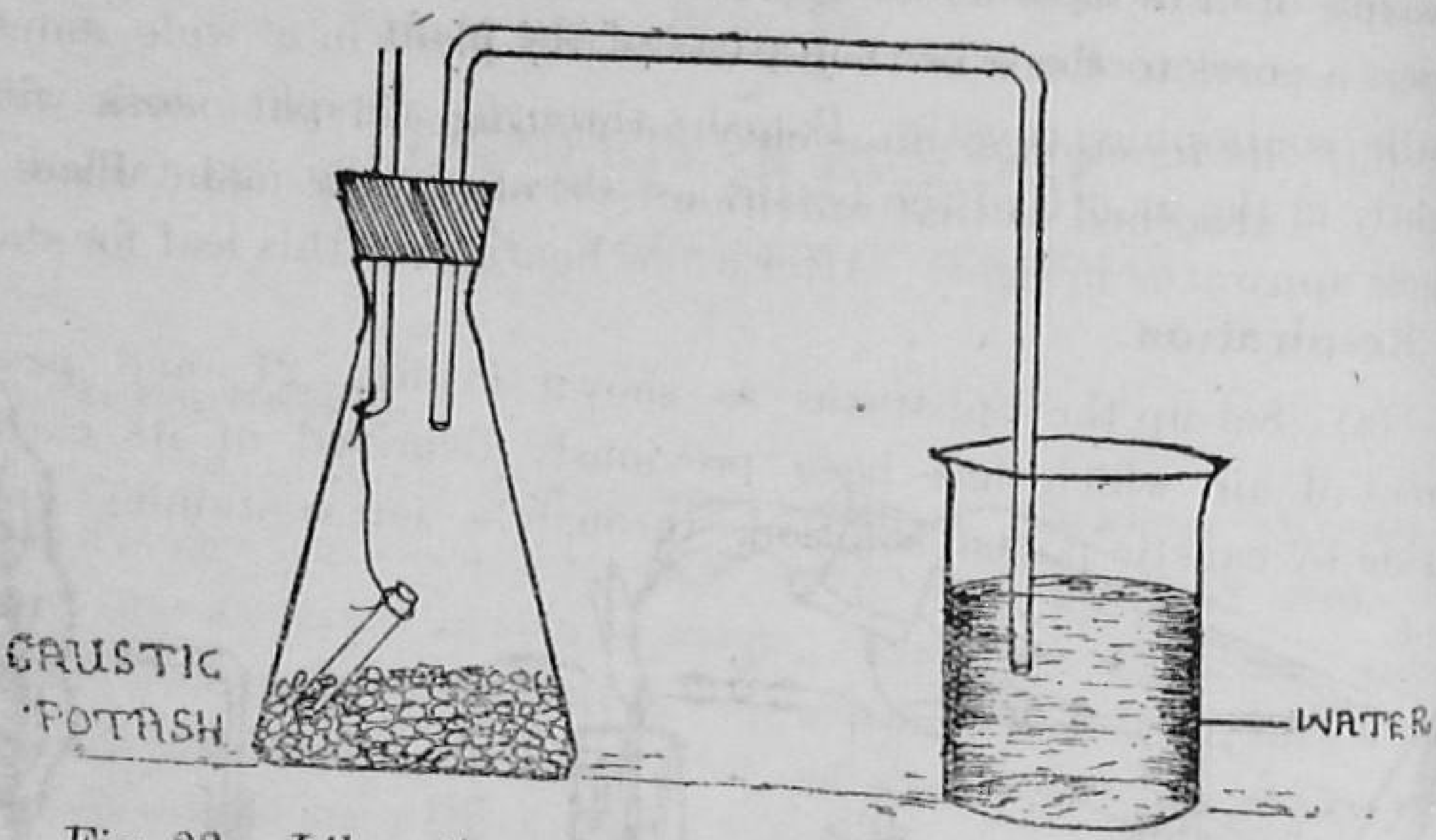


Fig. 22. Liberation of carbon dioxide during respiration.

(c) Put some germinating pea seeds or heads of living flowers in a wide mouthed bottle and keep it in the dark for a couple of days. Test the gas in the bottle, with a lighted splinter or lime water. Note down your observation and conclusion.

3. Photosynthesis.

(a) Cut a hundred discs from the leaves of healthy plants in the morning. Allow the plant to remain in sunlight and cut similar hundred discs from the same leaves in the evening. Note the increase in weight. This is due to the weight of the food prepared during the day.

(b) Insert a funnel over a mass of Elodea-plants in water and cover the ends with an inverted test tube filled with water. Note the production of bubbles when the apparatus is put in sun-light. Test the gas which is found to be oxygen.

(c) Test plants which have been kept in dark and in light for starch by iodine test. The former do not show any starch but the latter turn blue when iodine is applied.

4. Conditions essential for carbon assimilation.

(*a*) *Moll's experiment.* Put a green plant in darkness for a couple of days in order to deprive its leaves of all traces of starch. Insert a portion of one of the leaves of this plant in a wide mouthed bottle containing caustic Potash through a split cork fitting tightly in the mouth of the bottle as shown in fig. 23. Place the whole apparatus in light. After a few hours, test this leaf for starch.

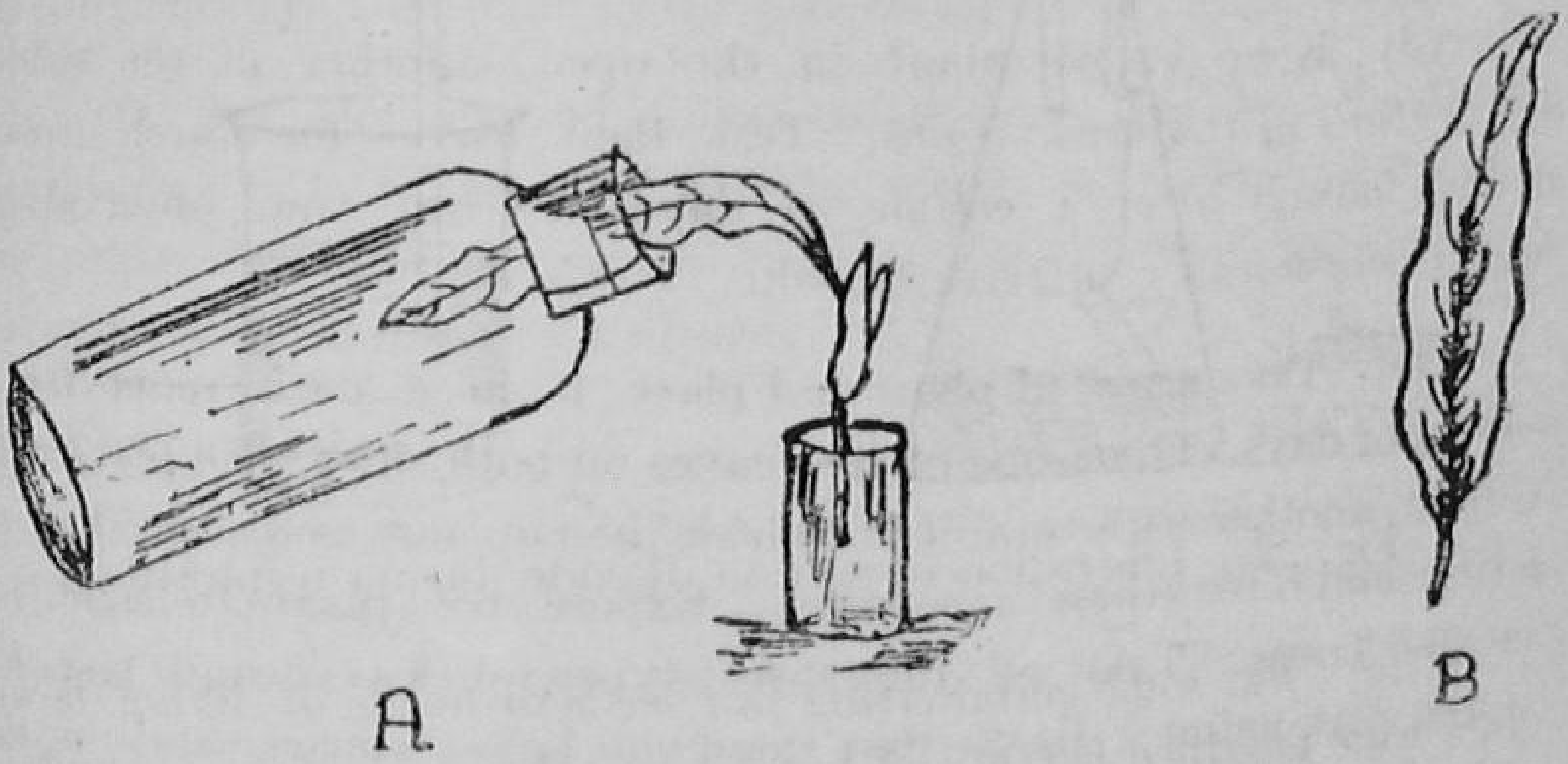


Fig. 23. Necessity of carbon for carbon assimilation.

Note :— (i) Your observation.

(ii) Your conclusion.

(*b*) *Importance of water.*

Experiment 2. Place potted plant in a dark room for two days to deprive its leaves of all starch present in them. Then remove two leaves. Stand one in water and place it in light, put the other in light too, but do not supply it with water. After about eight hours test both for starch.

Note (i) Your findings.

(ii) Your conclusion.

(*c*) *Bubble Experiment.* Take a branch of a submerged plant, like hydrillaor Patomogeton and put it in a vessel containing water.

Place the vessel in the sunshine. Numerous bubbles are given off in quick succession which may be collected by the upward displacement of water in a test tube inserted over the tail of a funnel covering the plant. When tested the gas is found to be oxygen. Bring the apparatus to a shaded place and note the change. Put the apparatus in perfect darkness and note the change.

Record your observation and conclusion in a record book.

(d) Keep one pot plant in the open, another in the shade and a third in the dark room. Test their leaves for starch (treat it with iodine) after a couple of days. Record your observation and conclusion in your record book.

(e) Take a potted plant and place it in a dark room for a couple of days. Cover one of the leaves on both sides with blackened tin-foil, another with tin-foil in which is cut out some pattern or letters and have others uncovered. Expose the plant to light for several hours. Take off the three types of leaves and test for starch with iodine. In the first there will be no starch, and in the second it would be found localized in the area cut out in the tin-foil, and the remaining leaves will show starch all over the surface.

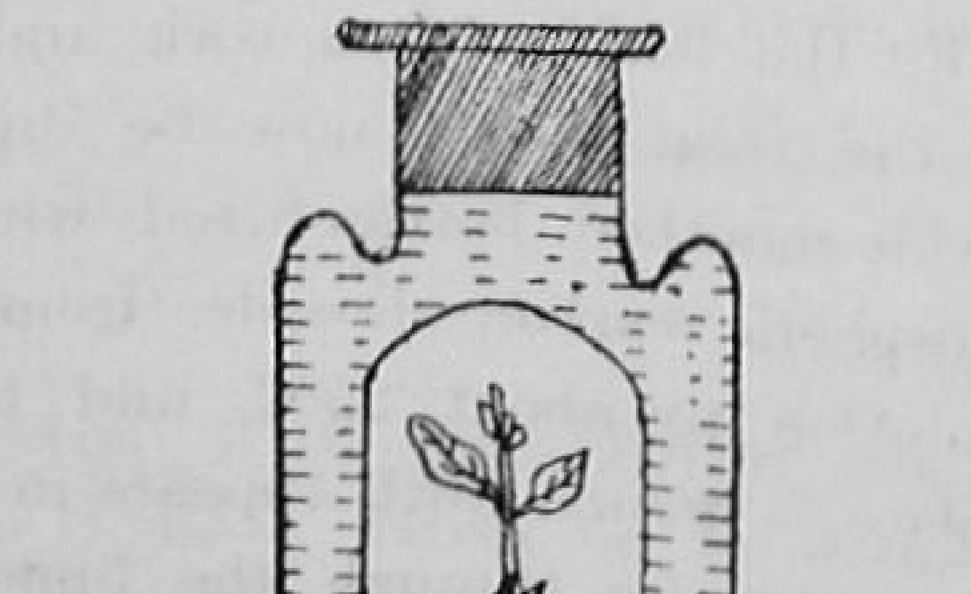


Fig. 24

In order to ascertain what colour is of most use in the process, two similar plants are grown under double water bell jars, containing a solution coloured blue by copper sulphate, and the other containing yellow solution of potassium bichromate. After sometime their leaves are tested for starch. Those in the blue light prove to be starchless. While those under yellow light show distinct formation of starch in them. This shows that yellow light is more effective than blue in the process of carbon assimilation.

(f) Try any spotted leaves with green patches for starch. In this type of leaf there are certain areas green with chlorophyll and others devoid of chlorophyll. It is noticed that no starch is present where chlorophyll is absent.

5. Fermentation.

Common examples of fermentation are alcoholic fermentation (conversion of sugar into alcohol by yeast), lactic acid fermentation (souring of milk), butyric acid fermentation (rancidity of butter), acetic acid fermentation (manufacture of vinegar from alcohol), etc.

(a) *Experiment on fermentation.* Dissolve 10 grams of sugar in 200 C.C. of water in a flask and add half an ounce of fresh brewers' yeast. Fit the flask with a cork and a twice bent tube. The free end of the tube should now be dipped into lime water contained in a wide-mouthed bottle fitted with a soda lime tube to prevent atmospheric carbon dioxide from entering the bottle. Warm the solution to about 25°C, and then leave the apparatus in a warm place. Soon a froth appears in the liquid, and bubbles of gas are seen to rise through the lime water which simultaneously turns milky, showing the presence of carbon dioxide formed in fermentation. A deposit of calcium carbonate is formed in the lime water. After about twenty four hours the presence of alcohol may be ascertained by its characteristic smell, in the flask. Moreover, by connecting a narrow straight tube to the flask and gently boiling the liquid, the vapour of alcohol may be ignited.

6. Geotropism.

(*a*) *Experiment.* Take a pot containing a young plant and rest

it on its side so that the stem lies horizontally. After a day or two the shoot will show a curvature due to more growth on the lower surface and thus will begin to grow upwards.

(*b*) *Experiment.* Fix a cork on one side of a flat disc by means of paraffin wax. Pour some mercury into it. Take a germinating pea or bean seedling and fix it to the cork by means of a pin in such a way that the tip of the radicle rests horizontally on the surface of mercury. Pour a little water over mercury and keep the apparatus in dark. A few days later it will be found that inspite of the resistance offered by mercury, the tip of the root bends and grows downwards into mercury.

(*c*) *Experiment.* Fix the radicles of some seedlings of pea or bean in the horizontal position in moist saw-dust and cover them with the same from above. After a day or so expose them and see that they have curved downwards due to more growth on the the upper surface.

(*d*) Try experiment by the help of clinostat.

7. Heliotropism.

Try experiment by the help of Heliotropic Chamber.

8. Water culture.

A complete culture solution :—

Solution A.

1. Distilled water	... ...	2 litres.
2. Pottassium Nitrate	... ...	1 gramme.
3. Ferrous Sulphate	... ...	0·5 "
4. Calcium Sulphate	... ...	0·25 "
5. Magnesium Sulphate	... ...	0·25 "

Solution B.

Make up a second similar solution containing 1 gramme of potassium chloride instead of the potassium nitrate.

Take two large (2 litre) cleaned and sterilized gas jars. Fill

one with solution A and the other with solution B. Choose two well fitting corks. Each cork has a slot through which the plant can pass and a hole to admit a glass tube. The cork is sterilized by passing it through a flame or by coating it with paraffin wax.

Water culture experiments.—Suitable plants for these experiments are those that grow easily from cuttings and seedlings containing no great reserve food (e.g. sunflower, marigold, etc.)

If using seedlings the roots must be well washed with distilled water. Each plant is then forced through the slot in the cork by a plug of cotton wool.

The experiment can now be started. Put the jars on a sunny window. Brown paper is wrapped round each to keep the roots dark. The solution should be aerated about once a week, a little air being pumped in a glass tube. If the experiment continues for some time it is as well to lift the plants each month, to wash the roots thoroughly in distilled water, to clean the gas-jars and refill with fresh solution. The result of each experiment should be noted and drawings made. In one of the jars complete solution should be put and in others solution deficient in one of the minerals.

9. Some special types of reproduction.

(i) Reproduction by binary fission e.g. amoeba.

Many simple organisms both plant and animal, particularly the unicellular ones, reproduce in this primitive manner.

Try to collect some amoeba from dirty water in ponds and ditches and examine them under a microscope. You may notice reproduction going on.

(ii) Budding is another simple method of reproduction which occurs in many plants and animals.

(iii) (a) Examine under a lens or microscope living hydras which have been well fed with Daphnia (water fleas). Buds are almost certain to be found on some of them and you may even be able to watch the detachment of one of these from its parent.

A very simple form of budding occurs in yeast plant.

(b) Remove some actively growing yeast cells from a sugar or other nutrient solution and examine them under the microscope. Chains of two, three or more cells are often to be seen.

(iv) Cut off the cap of a mushroom, place it on gummed paper slightly moistened and cover it with an inverted jam jar. After an hour or two you will obtain a 'spore print' of this fungus.

Spore formation is also a very common method of reproduction among green plants (e.g. mosses and ferns).

(v) *Grafting.* This involves fixing two pieces of plant tissue firmly against each other so that they eventually grow together. The tissues must be both living and of a similar nature. Usually one of the plants is still growing in the soil. This is called the stock. The method whereby the part of another plant is grafted on to the stock may be one of the following: *whip grafting* or *splice grafting.* In the former case the stock is cut across obliquely, then a vertical notch is made in the cut surface. The part of the other plant to be grafted on called the (scion or graft) is cut obliquely and made chisel shaped. The two are then dove tailed together so that the living tissue of each are brought into close contact with the other. The whole is tightly bound with wax or clay and then raffia or string tied round. After a few days or months it will be found that scion and the stock have grown together.

Splice grafting is simpler, in that both stock and scion are merely cut across obliquely and two cut surfaces fixed together.

The other method often used by the gardner is *budding.* In this case a stock is used, but instead of using a scion which is a complete small branch, only a bud is used. The bud is removed from its parent tree or bush together with a little stem tissue. A vertical cut is then made in the bark of the stock and a horizontal cut across the top of it giving a T shape. The corners of this incision are then lifted and the stem tissue of the bud inserted.

The whole is then bound with raffia or string until the bud grows on the stock. Eventually the bud develops and produces a branch on the stock similar to any branch taken. The stock above the new growth is cut away.

10. Observation.

The student should study the soil of his own locality and the various plant formations which grow on it. If he has a wood, hedge row, pond or other characteristic association near at hand, he will find it both interesting and instructive to watch the area all through the year to note the times and reasons of the various plant and animal inhabitants and to keep an illustrated record of their development ; to photograph them if he has a camera and to make a vegetation map of a small portion of the area, putting in every plant and every animal found in it.

The student should study the plants and animals in relation to their homes. The senior group too can attempt the observations suggested for the junior group. But their recordings should be more elaborate than of the juniors.

Herbarium should be made i.e. plant collection. Whenever any specimens of interest are found, they should be preserved with great care.

1. *Observation of living animals and insects.*

(a) Examine and draw a spider, notice the external features and habits, make record.

Water spiders are easily kept for a time in an aquarium. You should try to catch some and supply them with water weed, when they will construct their wonderful 'tents' for you before your eyes.

(b) *Bees, ants and tirmites.*

Notice the external features and draw them under magnifying glass ; make records of your findings. Make a study of their habits by observing them in different seasons with special reference to community living, division of labour, storage of food and construction of shelter.

(c) *Frog.*

Collect frog spawn in early spring and keep some in an aquarium. This may consist of a large pudding basin, if nothing better is available. There must be a plentiful supply of healthy water weed, and if the jar is small, water and weed should be frequently renewed. As the little animals develop there comes a stage when they like some animal food. A fragment of meat should be then attached to a length of cotton and lowered into the jar every morning. It may be left in position for an hour and then removed. If these instructions are followed no further attention is necessary until the creatures are preparing to leave the water. A platform of stones must then be provided.

Preserve in formalin specimens of various stages in the life history and make drawings of them.

(d) *Fish*

Observe and make sketches to illustrate the structure of any bony fish. Make a note of all the external characters.

Obtain the head and shoulders of a Rahu or other large bony fish. Observe the lidless eyes, nasal apertures, mouth, scales, teeth etc. Identify the operculum and the branchiostegal membrane. Lift it and and examine and draw the gill apparatus. Look inside the mouth, count the gill slits on each side. Identify the gill filaments and the gill rakers. Cut out one of the gills carefully, place it in water in a watch glass and draw.

Observe the movements of bony and cartilaginous fishes in an aquarium, and compare their actual movements with the account given in book descriptions.

Observe also their respiratory movements and make careful notes of what you see. Compare these movements in bony and cartilaginous fishes.

(e) Birds' habits can be observed if they are kept as pets. Try to have some pets and write about their behaviour. Migration and nest making also can be recorded. Examine the beak and feet of some birds. Classify according to their food.

(f) *Mammals.* Pets are easy to watch. Try to watch various mammals and record their habits. Try to classify ungulates, carnivores and rodents.

Find out odd toed and even toed ungulates. Observe the claws of dog and cat and find out the differences. Find out the structural adaptations which will help them to move without any noise.

2, *Growth in some animals and insects.*

(a) Weigh a batch of ten recently hatched caterpillars of the cabbage white or some other butterfly. Weigh them again after a week, and again at the end of the second week. Draw a graph showing the rate of growth.

(b) Divide some frog's spawn, water snails eggs, or other similar materials into two batches. Keep the one batch in a warm laboratory, the other under similar conditions, but in an unheated room. Make notes of times of hatching, rate of growth etc. The former group develops much more rapidly.

11. Examination of skeletons.

Examine and sketch (a) mounted skeletons (b) separate bones of certain vertebrate animals e.g. of a fish, frog, bird and a mammal. If possible examine one of a human being. You will probably find it possible to obtain the skeleton or parts of the same of a fish, domestic fowl, and a rabbit at home. Collect the bones of these creatures when they have been used for food, well boil them, and pick off the remaining flesh.

Take two rabbit bones and weigh each separately. Place one in dilute hydrochloric acid and leave for a week or two, changing the acid once or twice. Then dry the bone and weigh it again. It has lost some 67% of its weight and is now quite soft and flexible.

Break up the second bone and heat it strongly in a crucible. It becomes black, later it turns white, and finally all that is left is a crumbling brittle mass. Weigh this. It represents 33% of the original weight of the bone and contains all the mineral salts.

(These will dissolve in hydrochloric acid. Try this). The gelatinous frame work left when these salts were dissolved out from the first bone represented the organic substratum of the bone.

12. Collections

(a) Herbarium—Plants with all parts.

(b) Insects—Preserved with their natural colour.

(c) Birds—Stuffed and preserved.

(d) Vertebrates & Invertebrates—Preserved in formalin.

(e) Roots, fruits and seeds preserved in formalin.

13. Useful articles to be made.

(a) Decorations—made of shells, feathers, fish scales, bones, horns etc.

Egg shells are used for making toys.

(b) Bones especially long bones of stork and the common flamingo are used in making flutes.

(c) Horns—used in making fancy goods, toys, combs etc.

(d) Ivory—fancy and useful things.

(e) Products from coconut palm—coir from fibre, toys and fancy things from shells.

(f) Products from screwpine leaves—mats, bags, etc.

N. B. Visit the centres where these articles are made. Have demonstration lessons. Gradually collect the appliances and start from the easier articles.

14. Food.

(a) Study its function and constituents.

(b) Study in various courses of diets suitable for people of different ages-from a baby of six months to an old person of 80 years and also the ingredients of a balanced diet.

(c) Study a chart of food values of the common vegetables,

fruits and cereals in your city or village (such charts may be available from the nearest health centres). Study the availability, method of procurement and prices of these in different seasons.

(d) Prepare menus for all the meals for a week for a vegetarian family consisting of 3 adults, 2 old men, 2 school-going children and one baby in the arms prescribing balanced diets for all and keeping the cost to the minimum for the following seasons :

(i) Summer (ii) Winter (iii) Spring (iv) Rains.

(e) Repeat the above for a non-vegetarian family.

(f) *Experiment on methods of preparing tasteful food by keeping intact the nutritive value of different kinds of food-stuffs avoiding wastage, which is by*

(i) Skinning,

(ii) soaking the cereals and pulses for long and then throwing away the water in which these are soaked,

(iii) use of soda in cooking,

(iv) throwing away water in which vegetables and other kinds of food-stuff are boiled,

(v) cooking the food in an uncovered vessel,

(vi) over-boiling and frequent re-heating, and

(vii) frying.

(g) Try to make tasty and easily digestible salads of raw vegetables not used as such till now.

(h) Experiment on preparing food from skins of vegetables and peels of fruits keeping their nutritive value as far as possible.

(i) Try to find substitutes for staple food.

(j) Try to preserve fruits, vegetables and fish in season for use out of season.

15. Conservation of fuel.

I. Construction of the right type of oven by

(a) Keeping proper passage for oxygen to pass,

(b) leaving proper space between the flame and the cooking vessel so that the hottest part of the flame touches the vessel,

(c) leaving small side openings so that when the main opening is used for boiling or frying those may be used for simmering and stewing,

(d) having chamber adjacent to or under the main oven for baking and keeping hot the dishes cooked earlier, during the period of cooking,

(e) having a coating of mud if the oven is not made of mud or bricks so that heat may be conserved for a longer period.

II. *Use of right type of cooking vessel.*

(a) If the cooking vessel is of shining metal, the portion coming in contact with the flame should be given a thin coating of mud so as to prevent the heat being reflected back,

(b) the shape of the vessel should be such as to allow largest area to come in contact with the flame,

(c) the lid of the vessel should fit in closely at the mouth so that steam may be prevented from getting out. If necessary, put a heavy weight on the lid, so that maximum pressure may be maintained.

III. Use of the same oven for two or three vessels, one above the other so that the steam generated in the first comes in contact with the bottom of the second and that of the second with the bottom of the third thereby cooking the food in all simultaneously.

IV. Not keeping the fuel burning unnecessarily—

As soon as the cooking is over, fuel should be put off and kept for future use.

V. Making use of the small pieces of coal and charcoal and their dust by making balls thereof, mixed with mud and cow-dung.

VI. Making use of hay box or husk box. Take a wooden box provided with a lid padded with hay and stuff the box with hay or husk, leaving a little space in the centre for the vessel. Hay and husk are bad conductors of heat, therefore any heated vessel put in the hay box will maintain the temperature and the food will be cooked.

(a) Experiment on exactly how long you should keep the vessel on fire and how long in the box.

(b) Experiment on the construction of a hay box that will give the best results. (Try double box system).

16. Study of some of the diseases.

(a) *Malaria.*

1. Study the surroundings of your house and note if there is stagnant water anywhere.

2. Observe that in this water there are tiny larvae which move about in search of food and air.

3. Collect different types of mosquitoes from behind the wall papers, doors, and dark corners in the garden etc.

4. Compare these different types of mosquitoes and note the difference in their bodily structure, colour, size and method of sitting on the floor.

5. Note the season when malaria is in full swing.

Observe also that during rainy season mosquitoes are found in large numbers. Malaria is caused by the bite of the particular type of mosquito called Anopheles.

6. Study the signs and symptoms of malaria fever.

7. Note the temperature of the patient and record it in the temperature chart.

Note the fluctuations in the temperature.

8. Note the different stages of malarial fever i.e. the disease

after two, three and four days. Study the preventive measures and treat the infested places with insecticides.

Study the treatment of malaria patient in your locality.

Note down how many of them are getting proper diet and medicine. Impress on your neighbours the necessity for taking preventive measures.

(b) *Cholera*

1. Study the water sources of your locality and try to prevent pollution of water.

2. Find out whether food stuffs are kept and sold uncovered and contaminated by flies.

3. Can you corelate the outbreak of cholera during summer months ? Reason out the corelation.

4. Compare the number of malaria cases with the number of cholera cases within a week. The information can be obtained from municipality or health centres.

5. Note the precautions taken for the cholera patients.

Impress on your neighbours the necessity of inoculations and other preventive measures. Study as to what help may be obtained from the local bodies and hospitals- Find out whether the medical aid rendered by them is adequate.

(c) *Tuberculosis.*

1. Study the surroundings, and the locality where you reside. Find out if sufficient sunlight enters the houses, and they are properly ventilated.

2. Is there purdah system in your community ? Can you carry out campaign against the evils of purdah system ?

3. Find out the percentage of T.B. cases amongst the early married women.

4. Get the cows and buffaloes thoroughly examined for T.B.,

as bovine tuberculosis is spread through the infected milk of the diseased animal.

5. Study the diet of different families and find out whether they are taking balanced diet. Make suggestions wherever necessary.

6. Study the signs and symptoms and treatment given to T.B. patient.

7. Observe the precautions and treatment given to T.B. patient.

If there is a sanatorium in your town or nearby, try to visit it and find out the detailed treatment and type of care given to the patients.

8. Impress on your neighbours the importance of B.C.G. vaccination.

(d) *Measles and chicken pox.*

1. These diseases affect the children mostly. Find out the age at which chiidren are most prone to these.

2. Note the symptoms of these diseases and mark the points of difference.

3. Try to get statistics of incidence.

Find out how many of your neighbours are alive to the importance of isolation and observance of quarantine period. Try to find out the main causes of the spread of these diseases. Study preventive measures.

CHAPTER III

PART II

PROJECTS IN CHEMISTRY.

(For senior members of science clubs)

1. Air.

(a) Put phosphorus in a porcelain crucible and float it on water in a trough. Allow the phosphorus to burn and cover the crucible with a bell jar. Mark the water line of the bell jar by a rubber band. Phosphorus burns for some time and then the flame goes out. It will be found after sometime when the bell jar will be cooled that water level has come up to occupy about 1/5th the volume of the bell jar above the rubber band mark.

(b) Wet the inside of a long test tube or glass jar with water and put into it some iron filings. Move the jar so as to make the filings stick to the wall of it. Invert the tube in a dish of water. Mark the water line inside the jar with a rubber band and set it aside for a few days. It will be seen that iron filings will rust and water level will come up to occupy about 1/5th of the volume of the jar above the rubber band mark.

(c) Put some water in a test tube and boil it for several minutes to remove all the air in the test tube. Put a few clean iron nails. Remove it from fire and drop some oil on the surface of the water so as to form an air-tight covering. After a few days observe the iron nails.

Note your observation and conclusion.

2. Oxygen.

Preparation. Thoroughly mix about 9 gm. of potassium chlorate with about 3 gm. of manganese dioxide. Put the mixture in a hard glass test tube. Clamp the test tube loosely, slightly inclined to the horizontal position, and fix a good cork in its mouth carrying a delivery tube. The other end of the delivery tube

dips under a beehive shelf in a gas-trough filled with water. Gently heat the mixture in the test tube moving the flame about all the time. Take care that the hot mixture does not touch the cork. When bubbles of gas begin to come out of the delivery tube, allow the first few bubbles to escape. Then invert a gas jar, full of water, over the end of the delivery tube. Collect a jar full of gas and cover it with a gas jar cover. Similarly collect two test tubes of this gas and close the test tubes with good corks.

Properties :—

(a) (i) Take the jar containing oxygen. Hold a glowing wooden splinter in the gas and note down : (1) whether the gas supports burning.

(2) whether the gas itself burns.

(ii) Lower a small piece of lighted candle into the jar as in experiment (i).

Note down the results.

(iii) Take the first test tube. Put a little litmus solution into the test tube. Shake it and note down the results.

(iv) Take the second tube. Pour a little clear lime water into the tube of oxygen of experiment (iii). Close with the thumb and shake. Note down the result.

(b) Put a piece of wood charcoal in a deflagrating spoon and heat it red hot. Put it in the jar of oxygen, being careful not to let it touch the sides of the jar.

(1) Note down the result.

(2) After the charcoal has finished burning, take out the spoon ; add a little lime water, close the jar with a gas-jar cover and shake and note down the result.

(c) Put a little red phosphorus in a cool dry deflagrating spoon, and set fire to it by just touching it with a flame. Put the burning phosphorus into a jar of oxygen.

Note down your result and conclusion.

(d) Put some sulphur in a gas jar spoon. Hold it in flame. It melts and catches fire burning with a faint blue flame.

Put it in a jar of oxygen. Note down your results.

(e) Repeat (b) up to the point the charcoal finishes burning. Put a little water in the jar and shake it. Gas formed will be found to dissolve in water. Put a little blue litmus solution in the jar, it will turn red showing that the water in it has turned acid.

(f) Repeat (e) with (c) and (d).

(g) Heat a piece of sodium in the flame and put it into a jar of oxygen.

(1) Note down your observation.

(2) Put a little water in the jar and shake it ; the gas will dissolve in water.

(3) Put a little red litmus solution in this jar, it will turn blue.

(h) Repeat (g) with magnesium. Magnesium burns in oxygen with a blinding white light and forms white magnesium oxide. This dissolves in water slightly and the solution turns red litmus blue.

(i) Repeat (h) by burning calcium in oxygen and note down the observations.

(j) Heat a few thin iron wires red hot and dip them in a little powdered sulphur. The sulphur burns with a blue flame when the wires are lowered in a jar of oxygen. It burns with scintillation forming a blue-black iron oxide. This oxide will not dissolve in water.

3. Nitrogen.

(a) *Preparation.* Fix a crucible-lid on a flat cork floating in a gas trough containing a little water and put a small piece of

yellow phosphorus on the lid. Set fire to the phosphorus by touching it with a hot wire. Quickly invert a gas jar over the burning phosphorus. The phosphorus in burning combines with the oxygen of the air, forming phosphorus pentoxide, which we see, as a cloud of white powder filling the jar. After a little time, the phosphorus pentoxide dissolves in the water leaving nitrogen in the jar. Collect four jars of nitrogen.

(b) *Properties.* (i) Take the first jar. Find out whether the gas is soluble in water.

(ii) Take the second one. Put a lighted candle in it and find out whether it supports combustion.

(iii) Take the third one. Put blue litmus solution in it, and note the change.

(iv) Repeat experiment (iii) with red litmus.

4. Carbon dioxide

(a) Hold a clean dry gas-jar for a few seconds over a burning wooden splinter. Put a little clear lime water into the jar. Close the mouth of the jar with a cover and shake.

Note down your observation and conclusion.

(b) Repeat (a) with the help of

(i) a lighted candle,

(ii) the flame of an oil lamp,

(iii) the flame of a spirit lamp,

and (iv) the flame of a small Bunsen Burner.

(c) Breathe out in a clean dry test-tube, with a little lime water in it. Close the mouth of the tube with thumb and shake.

Note down your observation and conclusion.

(d) Set up the apparatus shown in fig. 25. Put clean lime water in test tube B. Put some solution of molasses and some rasin in the flask A. Leave it for a day or two. You will find

that the lime water in B turns chalky due to fermentation of molasses resulting in evolution of carbon dioxide.

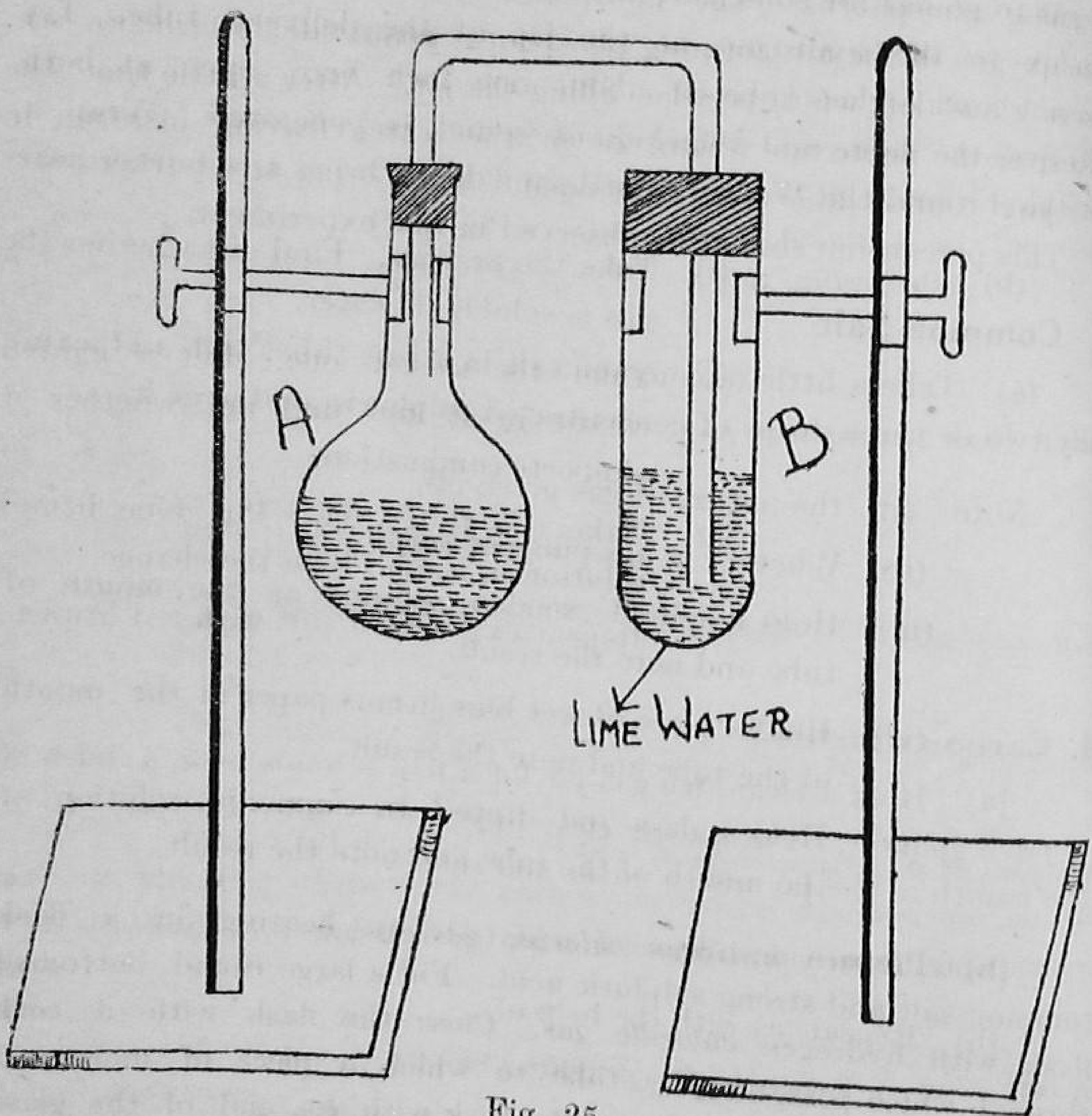


Fig. 25.

5. Water.

(a) Split water into hydrogen and oxygen by electrolysis of water using a cheap type of water voltameter.

(b) Throw a small piece of freshly cut sodium metal on the surface of water in a trough. Note that the metal dances about producing a hissing sound and then disappears. Dip a red litmus paper into the water in the trough. The red paper is at once turned blue.

6. Hydrogen

Singing flame.

Prepare hydrogen by the action of dilute sulphuric acid on zinc in Woulfe's bottle, and through a straight delivery tube allow the gas to go out for sometime till the whole of the air is driven out. Set fire to the hydrogen at the tip of the delivery tube. Try lowering a wide glass tube of about one inch bore, open at both ends over the flame and a melodious sound is generated. Wrap a wet towel round the Woulfe's bottle and do not bring any burner near it. This precaution should be observed in this experiment.

7. Common Salt.

(a) Take a little of common salt in a test tube and add carefully two or three drops of concentrated sulphuric acid over it.

Note (i) the nature of gas given off.

(ii) Whether it has pungent smell.

(iii) Hold a lighted wooden splinter at the mouth of tube and note the result.

(iv) Hold a piece of wet blue litmus paper at the mouth of the tube and note the result.

(v) Hold a glass rod dipped in ammonia solution at the mouth of the tube and note the result.

(b) Prepare *hydrogen chloride gas* by heating in a flask common salt and strong sulpluric acid. Fill a large round bottomed flask with hydrogen chloride gas. Close the flask with a cork through which passes a glass tube to which a piece of moistened filter paper is attached. Invert the flask with the end of the glass tube dipping under some water which has been coloured blue with litmus. The water slowly rises up the tube until, at first, a few drops enter the flask, and then it rushes up the glass tube forming a fountain inside until it is completely filled with water; and as the water rushes into the flask the blue litmus turns red.

N. B. This shows that—

(i) hrdrogen chloride is extremely soluble in water,

(ii) the solution is an acid,

and (iii) nature abhors vacuum.

8. Chlorine.

(a) Put a few petals of red rose in chlorine water in a beaker and note the result.

(b) Hold a starch-iodide paper in a jar of chlorine and note the result.

N. B. It will turn blue.

(c) Put some antimony powder in a jar of chlorine and note the result.

N. B. There will be a glow.

(d) Put some dry petals of red rose in a jar of chlorine and note the result.

N. B. Chlorine bleaches only in the presence of moisture.

9. Ammonia.

(a) Prepare some ammonia gas by heating some ammonia liquor. Fill a large round bottomed flask with ammonia gas. Close the flask with a cork through which passes a glass tube to which a piece of moistened filter paper is attached. Invert the flask with the end of the glass tube dipping under some water which has been coloured red with litmus. The water first rises up slowly in the tube until a few drops have entered the flask and it then rushes up the glass tube forming a fountain inside until the flask is completely filled with water. As the water rushes into the flask, so red litmus turns blue.

N. B. This shows (i) ammonia gas is extremely soluble in water,
(ii) the solution is alkaline, and
(iii) nature abhors vacuum.

(b) Suppose a bee stings you. Apply some ammonia to the affected part. The pain subsides. Ammonia neutralises the acid injected into the body with the sting.

(c) Collect one jar of ammonia and another of hydrochloric acid gas. Put the jar of hydrochloric acid gas over that of ammonia mouth to mouth. Carefully remove the covers of both the jars.

Note. (i) the flow of the gasses,

(ii) the cause for the flow,

(iii) whether any fumes are formed,

and (iv) the nature of the fumes and its cause.

10. Phosphorus.

(a) *Cold flame.* Boil phosphorus with water in a flask fitted with a cork, through which two glass tubes are passed; one of which reaches the bottom of the flask and the other serves as a delivery tube. A flame will be found at the end of the delivery tube as shown in fig. 26. Hold a paper in this flame. It will not burn.

(1) How is the flame generated ?

(2) Why is it so cool ?

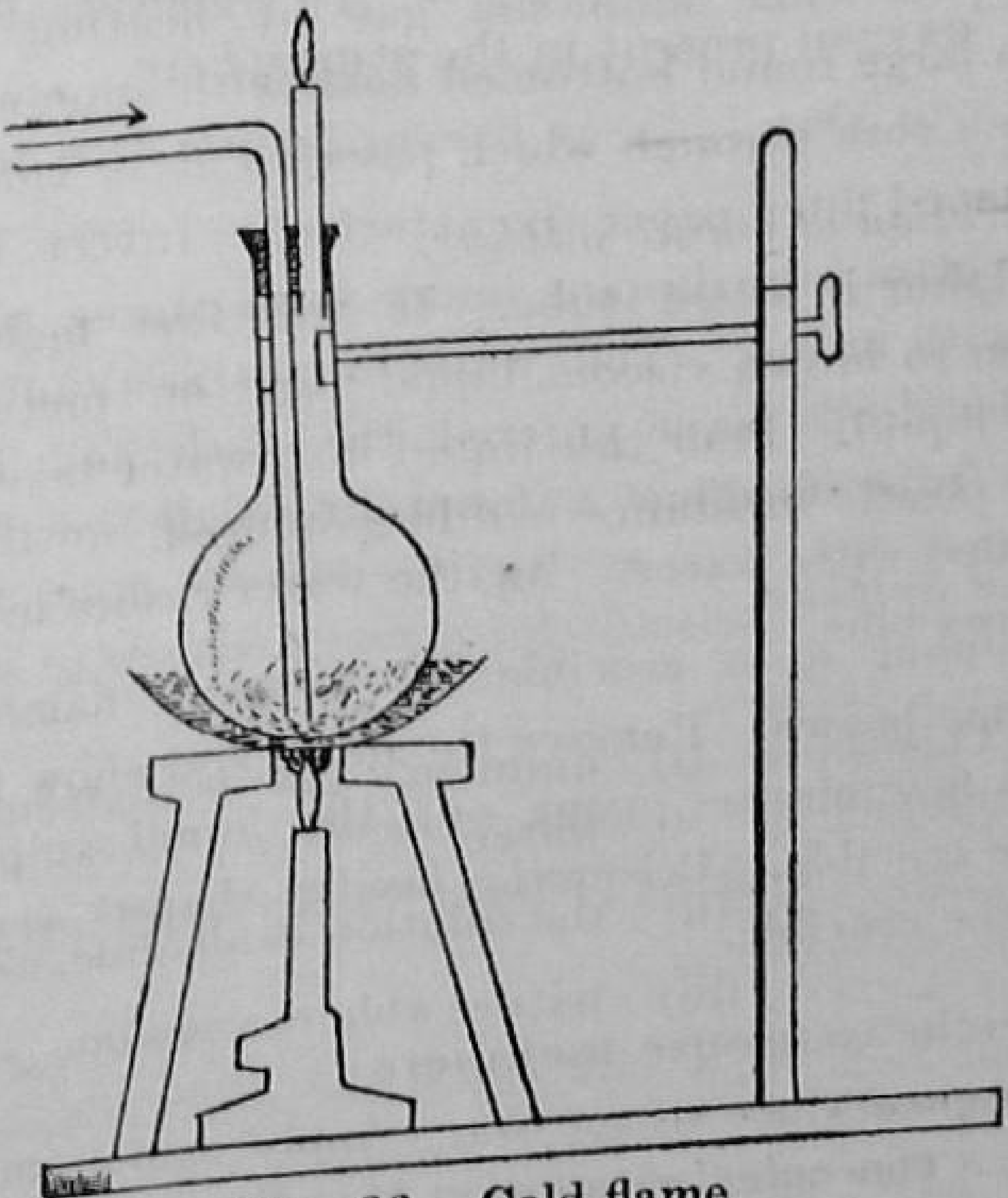


Fig. 26. Cold flame.

(b) *Fire under water.* Take a tall glass jar full of water and put a few bits of phosphorus at the bottom of the jar. A few crystals of potassium chlorate are also put inside the jar. By means of a thistle funnel pour concentrated sulphuric acid carefully so that it goes straight to the bottom of the jar. Phosphorus will continue to burn under water and fire will be visible under water.

N. B. Phosphorus burns due to its re-action with oxygen generated from potassium chlorate. Chlorine peroxide is first formed which decomposes giving oxygen. This oxygen is very active. Note that the bits of phosphorus cannot burn with the help of oxygen present in water and it will not burn even if oxygen is made to pass over it.

(c) Dissolve phosphorus in carbon disulphide in a test tube and by means of a brush write on a piece of blotting paper. When carbon disulphide will be evaporated away, yellow phosphorescent flame will be generated and the letters written will glow and become visible continuously from the first to the last.

N. B. Phosphorus burns to phosphorus pentoxide with oxygen present in the atmosphere.

11. Sulphur.

(a) *Preparation of plastic sulphur.*

Heat sulphur in a test tube. It will first melt to a yellow liquid and then to brown viscous liquid ; and on further heating to brown mobile liquid. Pour this liquid into water taken in a beaker. A rubber like plastic substance will be produced.

(b) *Crystal Sulphur.*

Melt sulphur in a crucible by a small flame so that it does not become brown. Remove the flame and allow the crucible to cool. After a few minutes, pour out the liquid sulphur which is still inside the crucible. Prismatic needle shaped crystals will be found inside the crucible.

12. Some tricks to amuse members

(a) *Silica garden.*

Prepare a concentrated solution of sodium silicate in a trough

and put some crystals of

(i) cobalt nitrate,

(ii) nickel sulphate,

(iii) manganese sulphate,

(iv) alum,

(v) copper sulphate,

and (vi) ferrous sulphate,

carefully at different places at the bottom of the trough without disturbing the solution in the trough. Silicates of these metals having different colours will be formed in tree-like forms. The whole trough will look like a garden.

(b) *Lead Tree.* Prepare a solution of lead acetate in a large beaker, and add a few drops of dilute acetic acid to the solution. Suspend a rod of zinc with a piece of thread from a glass rod placed horizontally over the beaker. Crystals of lead will be deposited on the zinc rod and will give it the shape of a tree having branches.

(c) *Formation of amorphous carbon.*

Heat sugar with sulphuric acid which results in the formation of amorphous carbon.

(d) *Crime detection.*

Finger prints brought to light by the help of aluminium powder :—

Put your finger marks on a piece of glass. You cannot see anything. Put some aluminium powder on it, rub it and remove it, you will be able to see the finger prints nicely.

(e) *Detection of borate.*

Burn a mixture of borax, alcohol, and sulphuric acid, you will get a beautiful green colour of ethyl borate.

(f) *Fire proof cloth.*

Take a piece of cloth; dip it in 50% spirit and light it. The spirit will burn and leave the cloth unburnt. This is a very simple but an attractive experiment for the members of a club.

(g) *Silver tree.*

Make a solution of silver nitrate in distilled water and grow a tree in it by adding mercury.

(h) *Chemical volcano.*

Ignite a heap of ammonium dichromate.

13. Developing photographic films.

The art of photography is based upon the sensitiveness of silver halides towards light. A photographic film which contains an emulsion of silver bromide in gelatin is exposed to an object in light, and an invisible image is thrown on the film by the lens of a camera, due to the incipient reduction of the silver halide upon which the light falls. The image thus produced is known as latent image and it is now developed by putting it in a solution of potassium ferrous oxalate, which reduces the exposed silver halide to black metallic silver.

The developed image contains metallic silver and silver bromide. It is made stable to light by 'fixing' i.e. by dissolving out the unchanged silver bromide in a bath of sodium thiosulphate called hypo. A negative is thus produced in which light and shade are reversed. Developing and fixing are done in a dark room in red light. A positive print is obtained by laying the negative on a printing paper, covered with an emulsion of silver chloride in gelatin, and then exposing it for some minutes to sunlight. The print is then developed and fixed as before.

14. Preparation of the following important articles.

Pain balm.

Camphor	... 1 part
Pepermint	... 3 parts
Oil of Dalchini	... 1 part
Oil of Cloves	... 1 part
Vaseline	... 30 parts

Ink. (Fountain Pen)

Amla	... 9 oz.

Cloves	...	1 dr.
Distilled Water	...	40 ozs.
Ferrous Sulphate	...	1½ oz.
Sulphuric Acid	...	25 drops
Indigo Carmine	...	½ oz.

Amla and cloves are allowed to be digested in water for 24 hours. The brown liquid is filtered. The solution of ferrous sulphate is added. After this sulphuric acid is added drop by drop and the mixture is quickly shaken. Finally indigo carmine is added and the mixture is allowed to stand for 15 days after which it is filtered to remove any suspended impurities.

Red Ink.

Eosine B	...	1 dram
Solution of Mercuric Chloride	...	2 drams
Mucilage of Acacia	...	2 drams
Spirit	...	4 oz.
Oil of Lavender	...	1 drop
Distilled Water	...	8 ounces

Dissolve Eosine in 2 ozs of water, add the mucilage and mix the oil dissolved in spirit and finally make up the volume.

Blue Ink.

Resorsin Blue	...	1 dram
Distilled Water	...	6 drams

Mix the colour and agitate thoroughly and add

Hot distilled water	...	24 oz.
Oxalic acid	...	10 grain
Sugar	...	½ oz.

Shake well.

Boot Polish.

The basis of all modern polish is wax—beeswax admixtured with a certain percentage of carnauba wax to impart shining properties, the vehicle being oil of turpentine. It is applied thinly over the leather and gently rubbed with a piece of soft cloth, when polish will result.

Characteristics of a good polish :—

(a) It should give a brilliant polish without much rubbing.

(b) It should protect the shoe from the action of heat and water and render it supple, non-sticky and water-proof.

Beeswax	... 2 parts
Carnauba Wax	... 1 part
Paraffin Wax	... 14 parts
Yellow Soap	... $\frac{1}{2}$ part
Saponified Stearin	... 2 parts
Turpentine Oil	... $2\frac{1}{2}$ times of the total weight

Procedure.

Cut the soap in thin slices and dissolve in smallest quantity of water by gentle heat. Melt the waxes together and then add the oil of turpentine (after taking away from fire). Add nigrosin for black polish and bismark brown for brown polish.

15. Consult some books on industrial chemistry and prepare the following articles :—

(a) Vinegar
(b) Hair oil
(c) Laundry soap
(d) Paints
(e) Wood polishes.

CHAPTER III

PART III

PROJECTS IN PHYSICS

(For senior members)

I. Light.

1. To set up a periscope.

Make a long cylindrical or a square tube of cardboard or wood. Fix at the edges of the tube two plane mirrors and make them parallel to each other. Fix two small tubes in opposite directions to this tube covering the mirrors. The upper mirror can be turned towards the object. The rays of light from the object are reflected by the upper mirror along the axis of the tube, and after being reflected by the lower mirror reach the eye of the observer thereby giving him a view of the object as shown in fig. 27.

With it view an object out of a window keeping your head below the level of the window by looking in the lower mirror through the side tube.

This arrangement can be used to witness a game over the heads of a crowd.

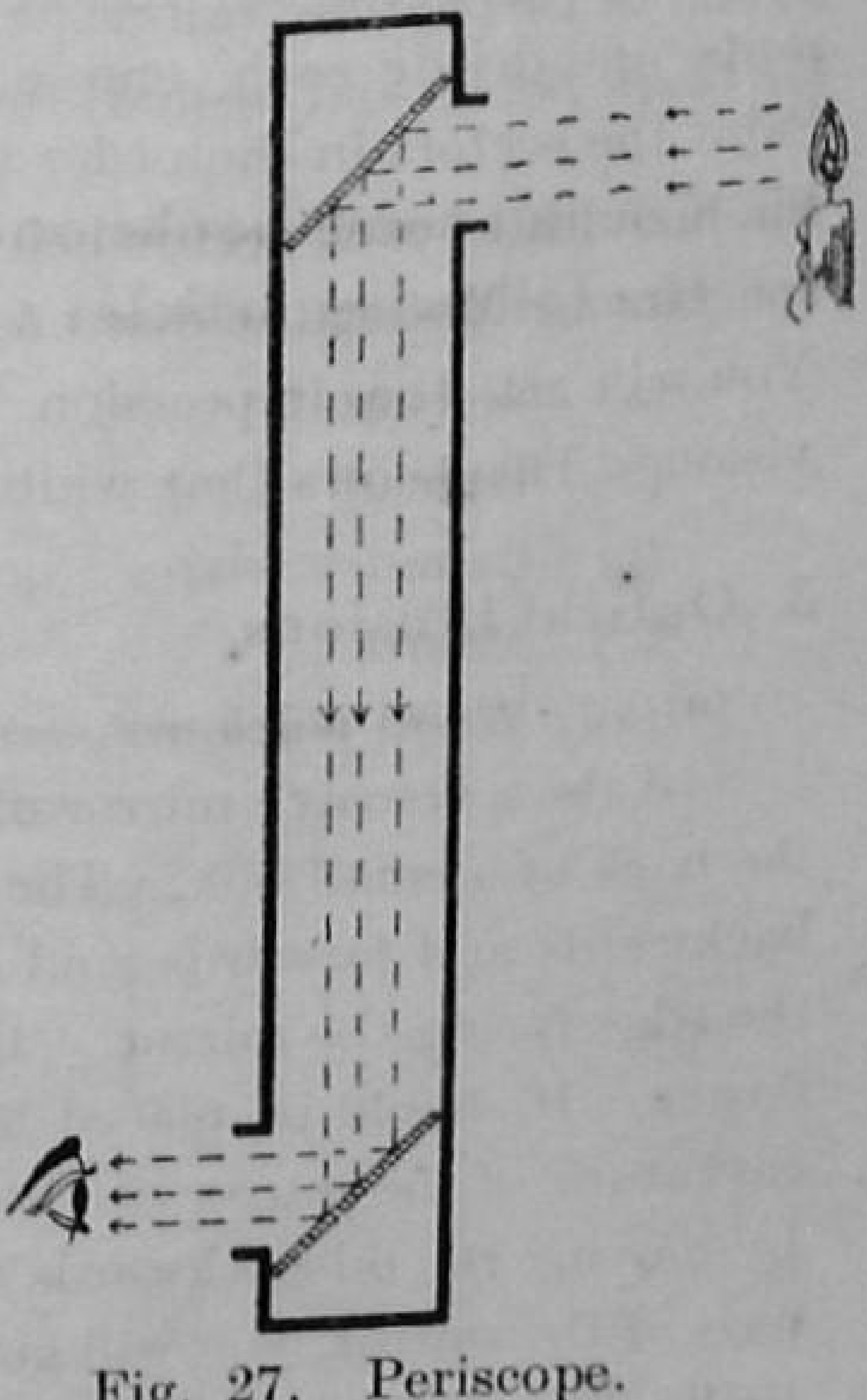


Fig. 27. Periscope.

2 Experiments to illustrate persistence of vision.

(a) *Parrot inside the cage.*

Draw the picture of a parrot on a paper and that of the cage

on another. Fix these pictures on opposite sides of a piece of cardboard. Mount the cardboard on a whirling table and set it revolving. The parrot will appear inside the cage, as long as the card-board will continue to move. When a certain impression falls on the retina of the eye, it lasts from 1/10th to 1/16th of a second. The impression of the parrot is not effaced from the retina when that due to the cage also falls on it. The blending of these impressions gives the illusion.

(b) *Impression of welcome.*

Write W L O E on one side of a cardboard, and the letters E C M on the other. Mount the cardboard on the whirling table. On revolving the table, you will get the impression of the word 'WELCOME'. The effect is due to persistence of vision.

(c) *Composition of white light.*

Take a disc about 10″ in diameter. Divide it into four quad-rants, and divide each one of these quadrants into seven sectors. Paint the sectors in the order of the colours of the solar spectrum, the breadth of each sector being proportional to the width of the spectrum. Mount the disc on a revolving table, and set it revolving. You will get the impression of white light due to persistence of vision. This shows that white light is composed of seven colours.

3. Optical Illusions.

(a) *To try to pluck a flower.*

Take a concave mirror of small focus and fix it vertically to the back of a small box. The lid of the box should be able to slide backwards and forwards, and should have a semi-circular cut in it on the edge facing the mirror. To the lower surface of the lid, attach a flower. It should be placed between the focus and the centre of curvature of the mirror and its proper position can be found by trial by moving the lid backwards and forwards. When looking along the axis of the mirror, you will get an enlarged image of the object above thelid Try to pluck the flower above the lid and yon will find that it is unreal. The diagram 28., simply shows a flower hidden by an obstacle from the view of the observer, and shows the rays that enable the image to be formed.

For getting a spectacular effect, it is necessary that an electric lamp should be fixed inside the box so as to illuminate the object.

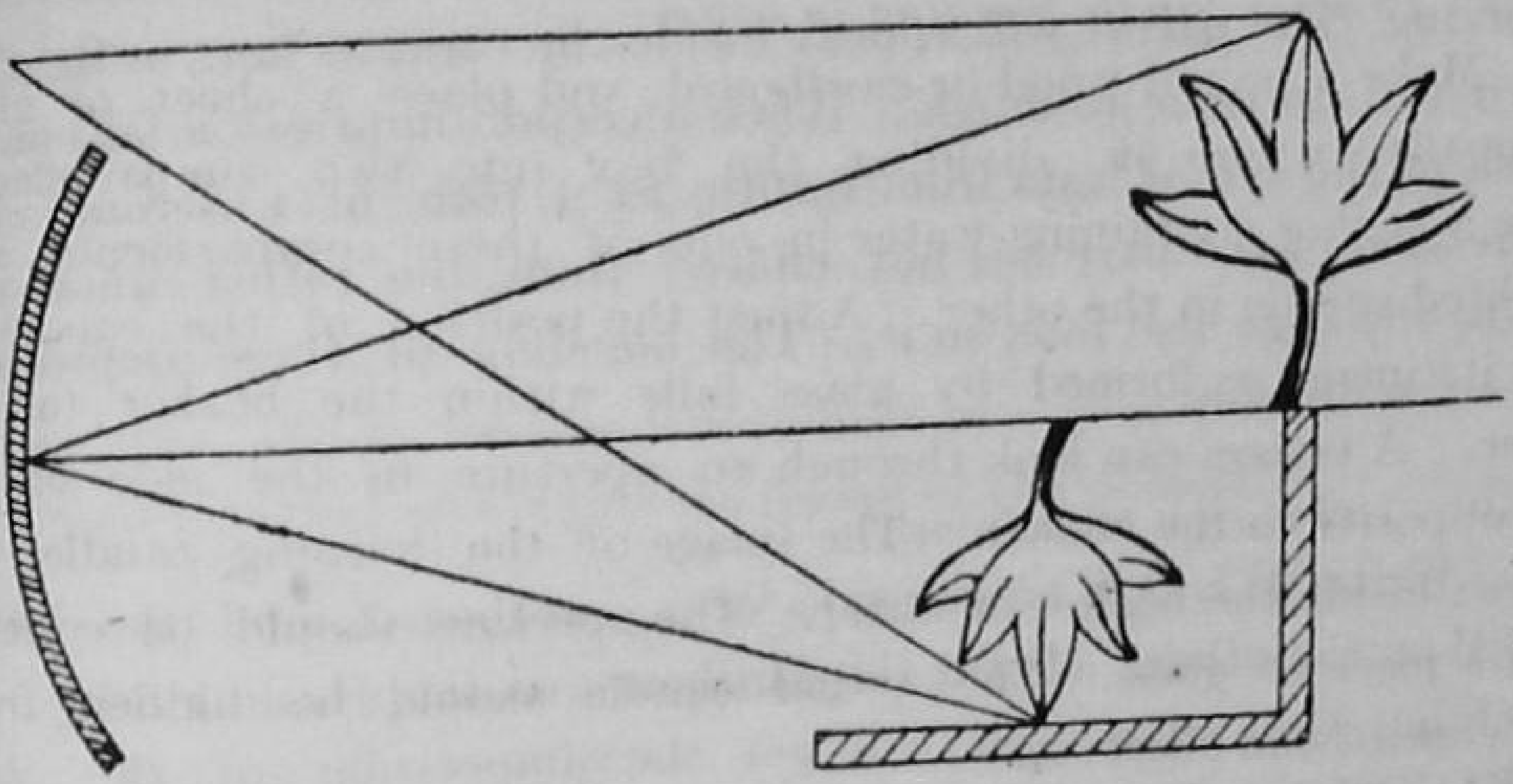


Fig. 28. Concave mirror illusion.

(b) *Experiment to show vision through brick.*

Arrange four plane mirrors, M_1, M_2, M_3 and M_4 in a box, as shown in fig. 29. The mirrors M_1 and M_2 are fixed parallel to each other. Similarly the mirrors M_3 and M_4 are fixed parallel to each other. Place a lighted candle in front of the tube A, and looking through B you will be able to see its image, though there is a brick or a book between the object and the observer. The path of rays are shown in the diagram. The effect is due to successive reflections of light from the surfaces of mirrors.

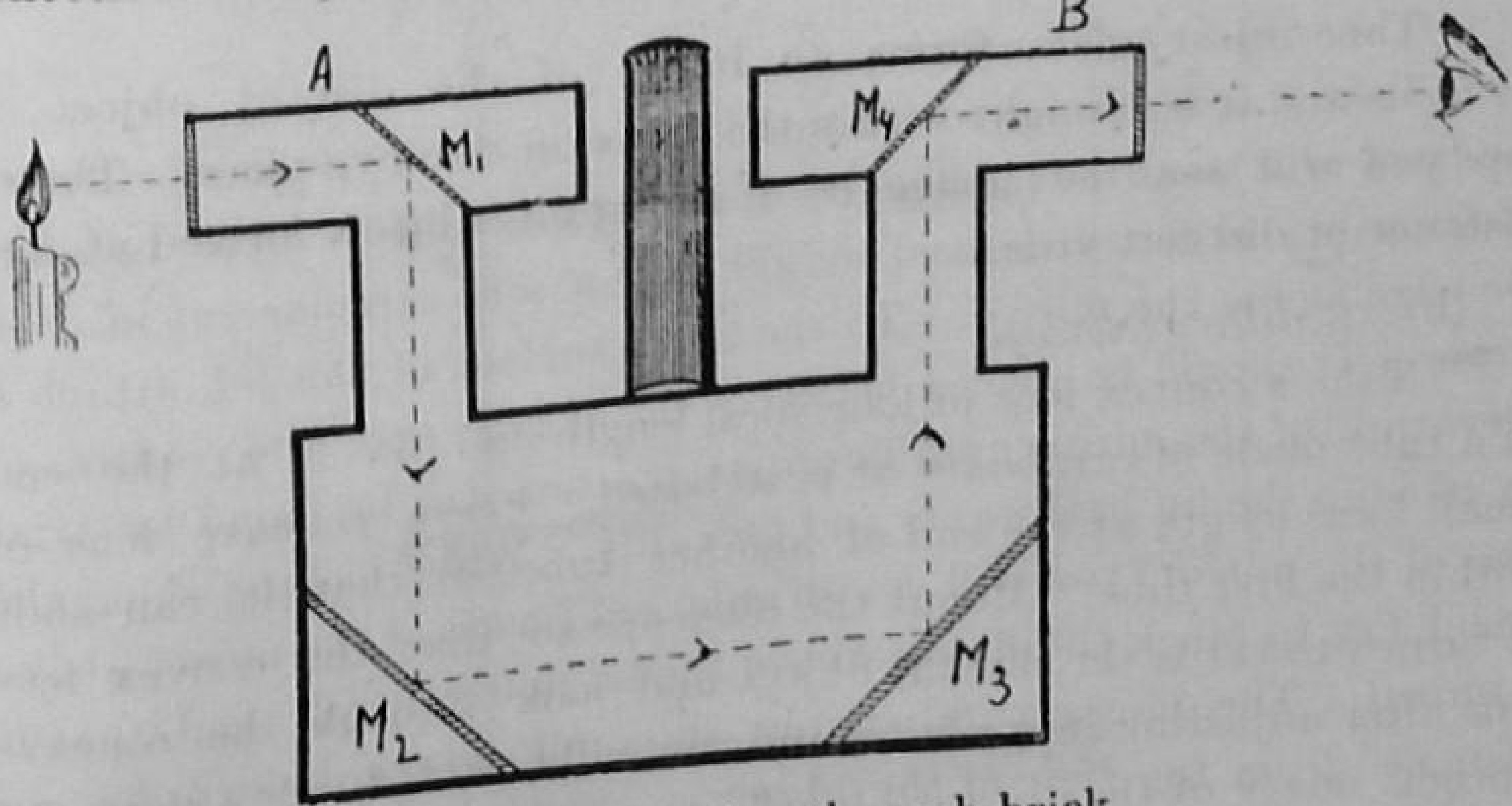


Fig. 29. Vision through brick.

You can, if you like, join two periscopes together for this experiment.

(c) *To see a candle burning in water.*

Make a box of wood or cardboard, and place a sheet of glass diagonally across it, dividing the box into two compartments. Place a beaker containing water in one of these comparments, and a lighted candle in the other. Adjust the position of the candle so that its image as formed by glass falls within the beaker full of water. A person can look through an aperture in the side of the box opposite to the beaker. The image of the burning candle will appear inside the beaker of water. The aperture should be covered with a piece of glass. The actual candle should be hidden from the view of the observer.

4. To set up the models of telescopes and microscopes.

(a) *Astronomical telescope.*

Select two convex lenses of different focal lengths, and one of these should be of longer focal length than the other. The lens of longer focal length will serve as the *object glass*, and the other as *eye-piece* Take cardboard or pasteboard and make a tube out of it, and fix the convex lens of longer focal length at its one end. Make another tube and fix the second lens at its one end and let this small tube slide within the other tube. Mount the telescope so made, and look through the eye-piece, and you will be able to see a clear, inverted image of the distant object.

The object glass forms an image of the distant object at its focus and it is brought within the focus of the eye-piece. Therefore you will see the image of the distant object formed at the distance of distinct vision.

(b) *Galileo's telescope.*

Take a convex lens of long focal length and fix it at the end of a tube made of cardboard or pasteboard. Fix a concave lens of small focal length at the end of another tube so that it can slide within the first tube. Mount the telescope so that the convex lens is turned towards the distant object and look through the concave lens after adjusting its position and you will be able to see a clear and upright image of the distant object.

(c) *Compound microscope.*

Select two convex lenses of different focal lengths. The lens of smaller focal length will serve as the object glass, and the other as eye-piece. Fix the lens of smaller focal length at the end of a tube made of cardboard or pasteboard, and the lens of longer focal length at the end of another tube so that this tube can slide within the first tube. Mount the microscope and place an object near the object glass, and on looking through the eye-piece you will be able to see an inverted and magnified image of the object.

(d) *To set up a water microscope.*

Fix a metal plate to a stand, and bore a small hole in it. Below the metal plate place a glass plate on which the object like an ant can be placed. Put a drop of water in the hole in the upper metal plate, which will act like a lens. Look through it and the object will appear to be magnified. The position of the object can be adjusted by moving the plate up or down. A plane mirror may be placed below the object and it may be used for throwing light on the object as shown in fig. 30.

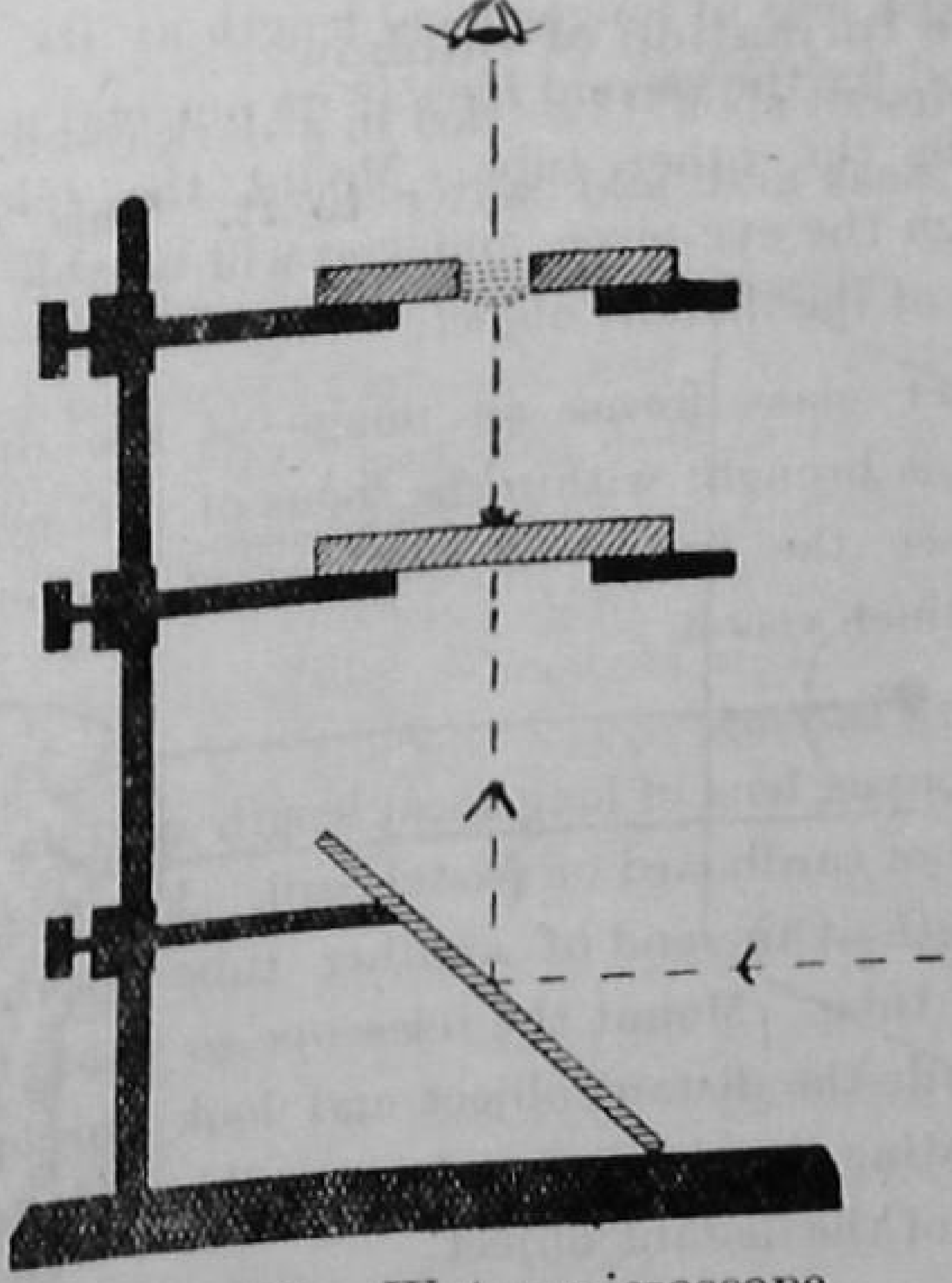


Fig. 30. Water microscope.

5. To make an episcope.

Experiment to illustrate the method of projecting a picture of a book on a screen.

Make a rectangular box 1 ft. long, 1 ft. broad and 1 ft. high, which should be light-tight. Cut a hole of 4" diameter in one of tis faces.

Make a tube about six inches long by rolling a piece of sheet tin and by soldering its edges. Make another tube of half the length of the first tube and of such a diameter that it can just slip over the first tube. Fix the second tube to the box, and hold a lens in position near the end of the first tube by wire rings.

The back of the box should have a small hinged door. Place the picture which is to be projected against this door by pins. Fix two lamp holders inside the box opposite to the picture and fix lamps in them. Light the lamps so as to illuminate the pictnre and focus the image on the screen by moving the lens backwards or forwards. The experiment should be tried in a dark room.

An episcope is used for opaque projections.

6. To study the formation of rainbow.

This experiment should be tried in a dark room. Take a small round bottomed flask and add water to it. This will serve as a

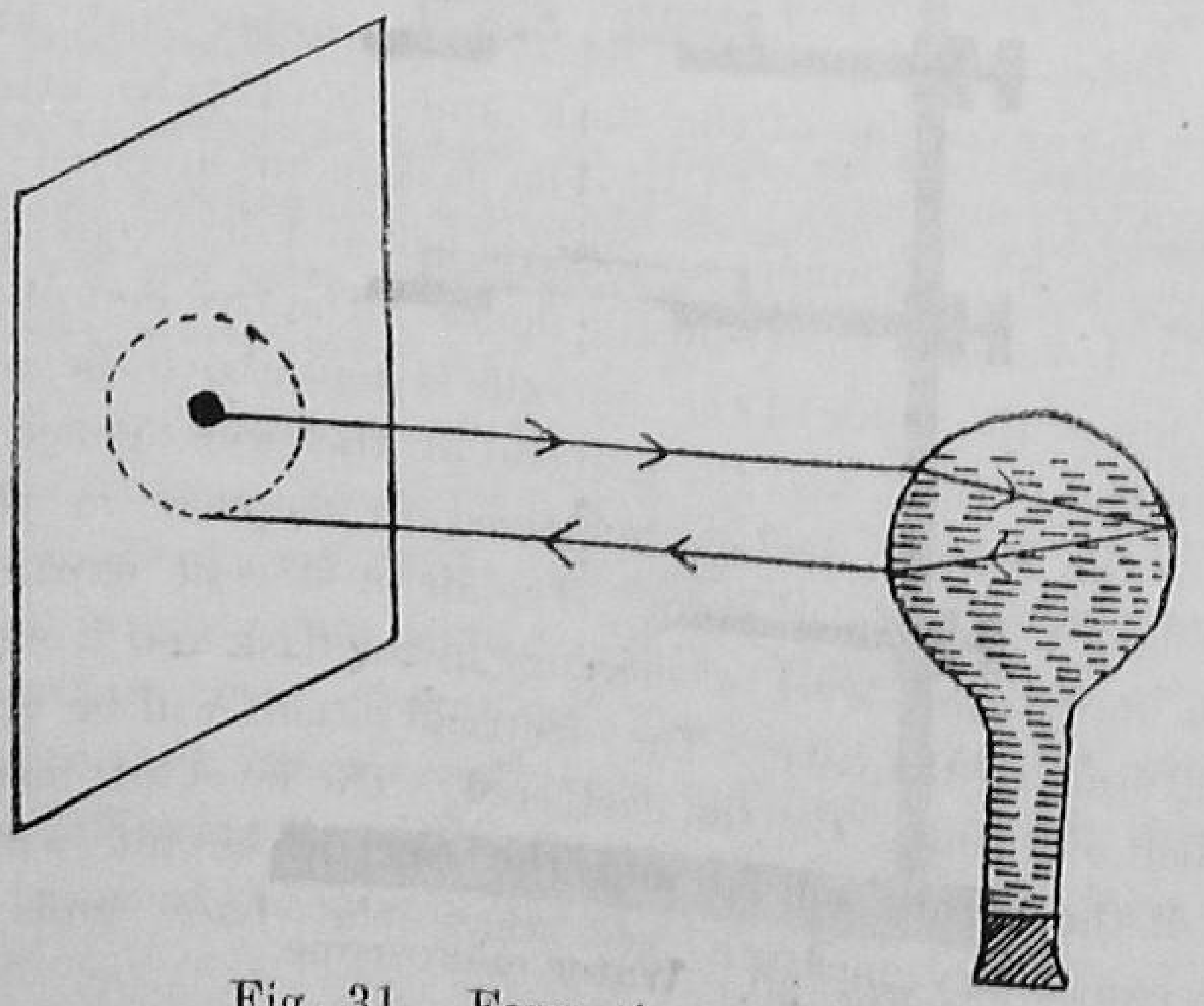


Fig. 31. Formation of rainbow.

drop of water. Take a strong source of light and place a cardboard having a hole in it in front of the source of light as shown in fig. 31. Allow the beam of light to fall on the drop of water. A spectrum will be formed on the cardboard. Study the colours that you observe in the spectrum, which is formed on account of refraction and reflection of light by water.

7. To study the phenomenon of mirage.

Mirage is a phenomenon which is observed in deserts. It is an optical illusion, and due to it images of distant objects are seen as if reflected from the surface of water.

For studying mirage take a long rectangular sheet of asbestos and fix lengthwise in the middle of the sheet a coil of nichrome wire. Fix an electric bulb at one end of the sheet of asbestos and look at it from the other end after heating the wire electrically. You will be able to see the image of the bulb in the hot air above the heated wire.

II. Experiments on heat.

1. Fire alarm.

(a) Take a flask and fit in its neck a rubber cork and a U-tube. The lower portion of the flask and the U-tube attached to it should contain mercury. Clamp the flask in an inverted position, as shown in fig. 32. Connect an electric bell and dry cells joined in series to the U-tube as shown in the figure. The free end of the wire joined to one of the poles of the dry cells is kept above the surface of mercury in the U-tube, and the free end of the wire joined to one terminal of the electric bell is immersed in mercury in the tube. Heat the flask with a spirit lamp. The air in it will expand which will push down the level of mercury in the flask and it will rise in the second limb of the tube. The electrcial circuit will be completed and the bell will ring. Let the flask cool. The level of mercury in the limb of the U-tube will fall and the electric circuit will break. As a precautionary measure see that the bare ends of the

two wires do not come in contact with each other directly inside the U-tube.

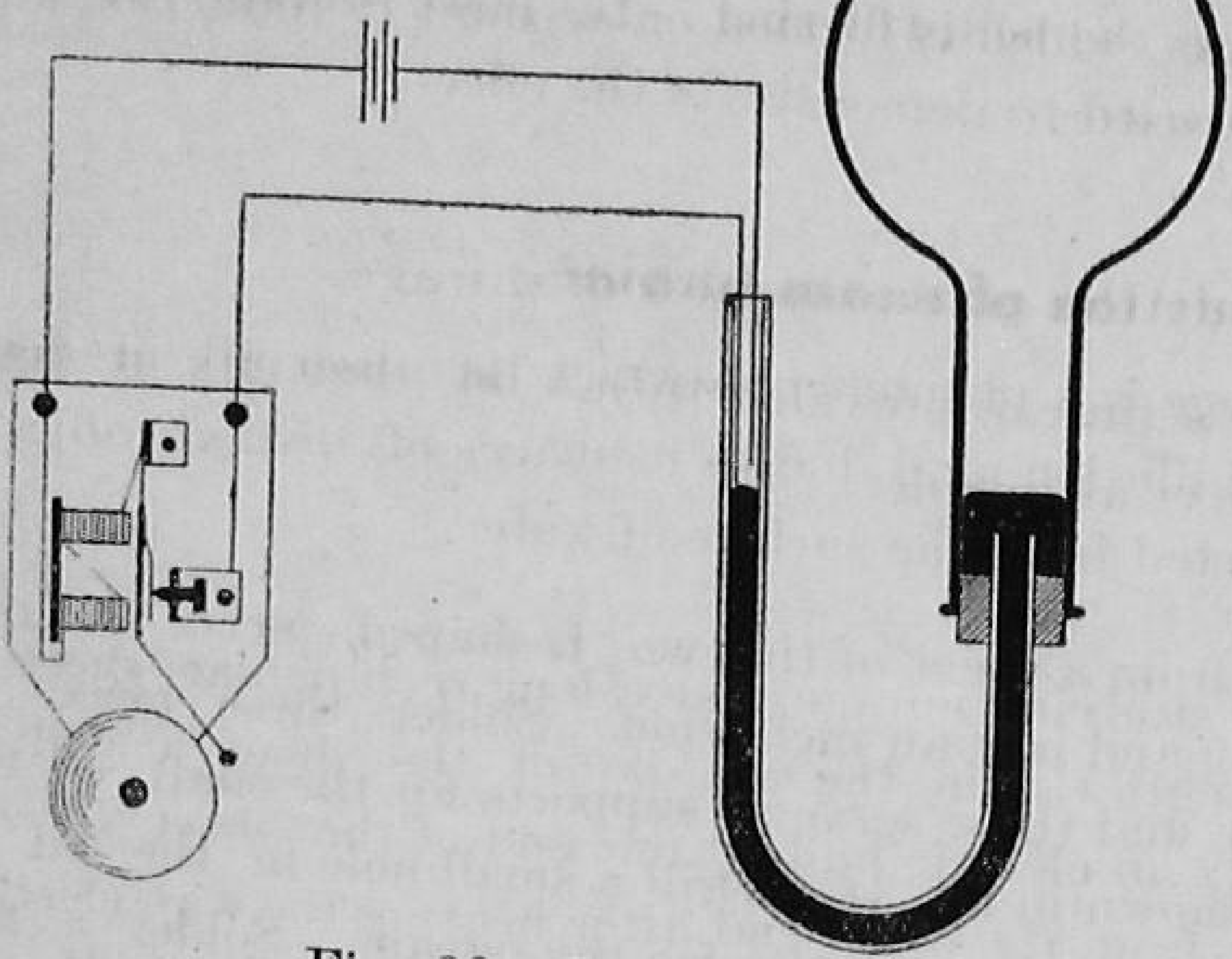


Fig. 32. Fire alarm.

(b) There is another way of setting up a fire alarm. Take a long wire and stretch it across the room and support a metal plate

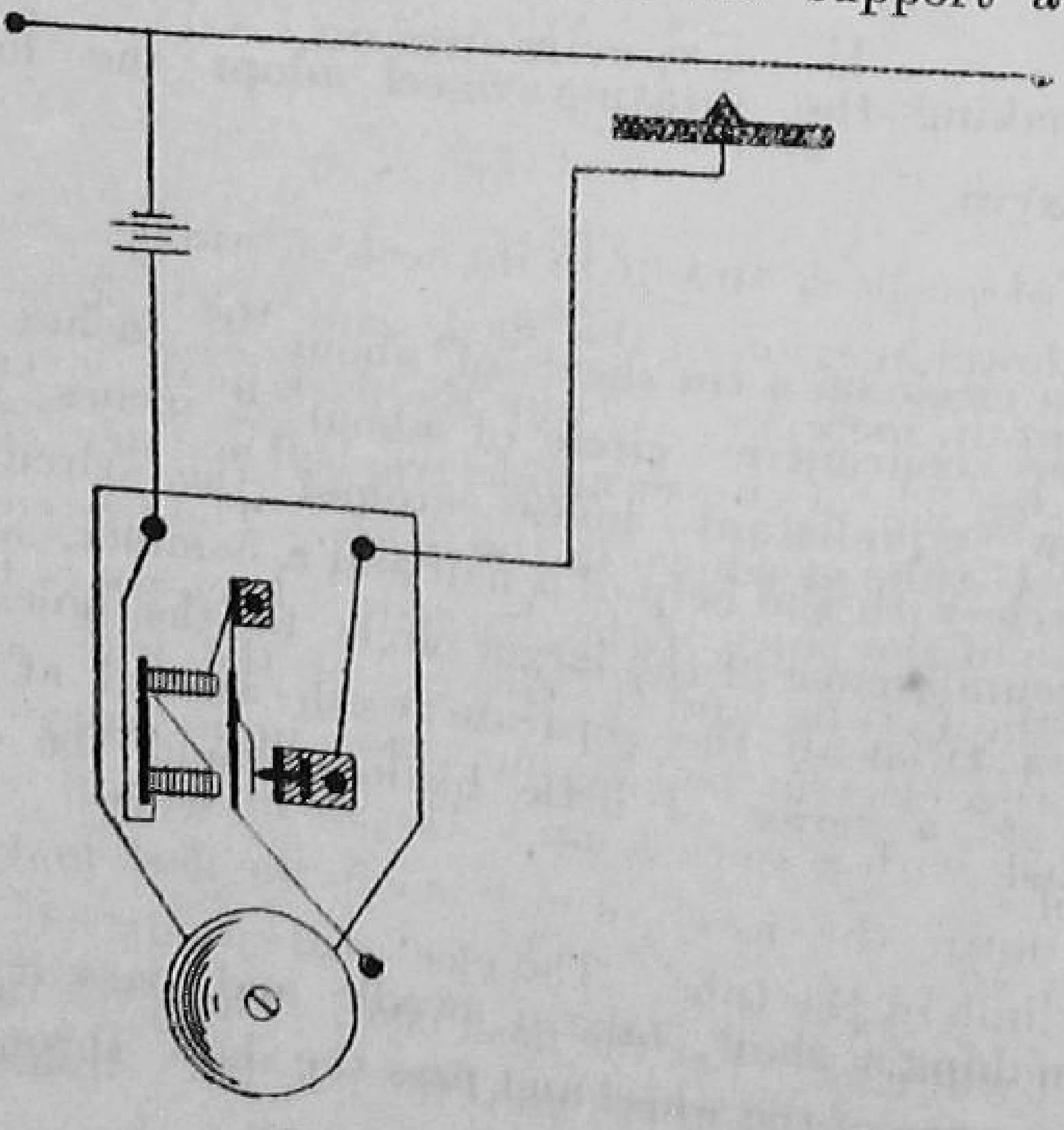


Fig. 33. Fire alarm.

just below it, as shown in fig. 33. Take a bell and a battery and connect them to the long wire and the metal plate, as shown in fig. 33. Heat the wire. It will sag due to expansion, and will come in contact with the plate. As the electrical circuit will be completed, so the bell will ring. In place of the bell, an electric bulb can be used to demonstrate the effect.

2. Construction of steam turbine.

Take a tin can provided with a lid that fits it tightly. This can will serve as a boiler.

Cut from a sheet of tin two L-shaped pieces each about two inches long and half an inch wide. Solder these pieces to the top of the can, and these serve as supports for the shaft of the rotating wheel as shown in fig. 34. Drill a small hole in the lid of the can which will serve as an outlet for the steam. Solder a tube to the lid at this place so that the issuing steam is directed against the teeth of the rotating wheel.

For making the rotating wheel adopt the following procedure:—

Draw a circle on a tin sheet of about $2\frac{1}{2}$ inches in diameter and another concentric circle of about 2 inches in diameter. Bore a few equidistant holes around the circumference of the small circle with the help of a nail and a hammer, and cut slots from the circumference of the larger circle to the holes. With the help of pliers twist all the separate teeth around at right angles so that we get a series of little blades around the circumference of the wheel.

For making a shaft, take a needle and pass it through the hole in the centre of the wheel and pass the shaft through the holes made in the two supports.

Pour water inside the can and boil it and let the issuing steam play upon the blades of the rotating wheel which will consequently begin to rotate.

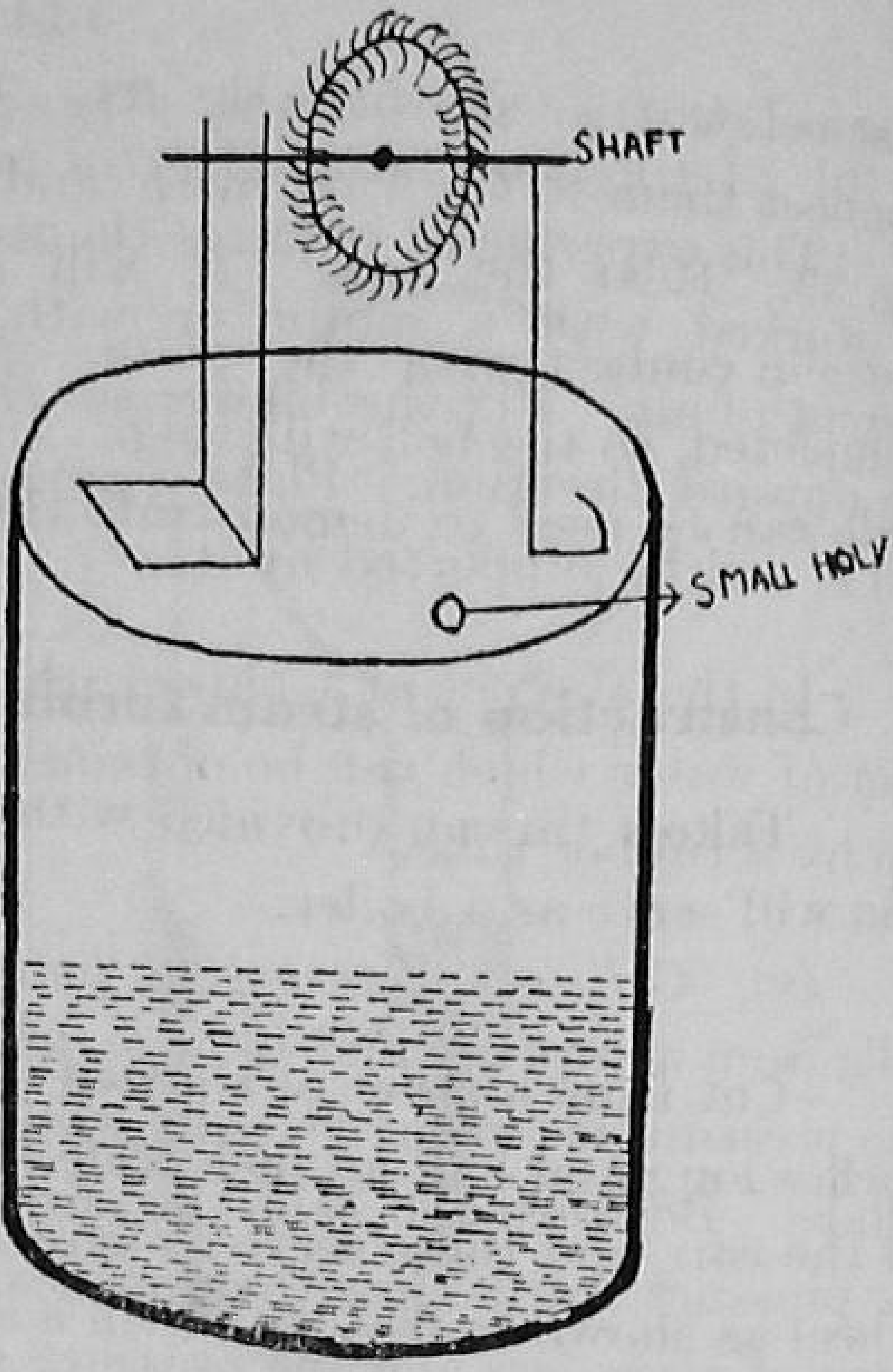


Fig. 34. Steam Turbine.

Mechanics.

1. How a jet produces a vacuum ?

(a) Take a glass tube and fix to it a disc made of cardboard. Place the tube above the empty outer part of a match box as shown in fig. 35. Blow down the tube, and you will be able to lift the box by raising the tube while still blowing down it.

The air spreads out from the tube to the outer edge of the disc. During this process its speed decreases. At the outer edge the pressure is atmospheric, and inside the disc the pressure is less than atmospheric. The box will rise due to excess of pressure below it.

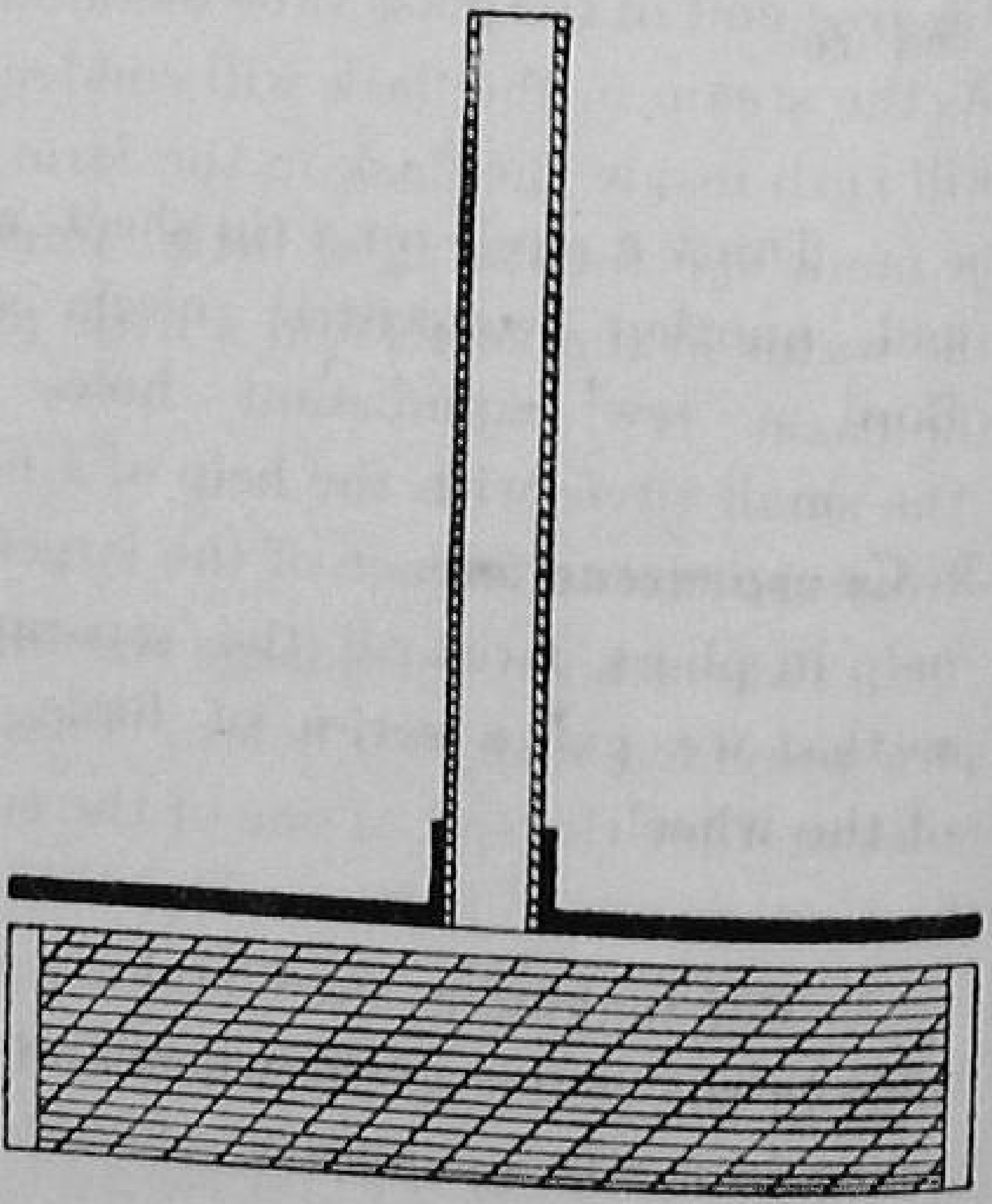


Fig. 35.

(b) *A ping pong ball supported in air.*

This experiment requires the use of a blower which can either be worked with a motor or with hand. It will produce a strong current of air. Fix the blower so that the current of air goes in the upward direction. Place a ping-pong ball in the current of air, and it will be supported by it.

In the absence of a blower, the experiment can be tried with a jet of water which can be obtained by fixing a jet tube to a water tap by a rubber tube.

(c) *Collision of ping-pong balls.* Hang two tennis or ping-pong balls from a support and blow a jet of air upward between them. The pressure between the balls will decrease and the two balls will collide. Between the balls the air has considerable speed and so the pressure will be less than atmospheric, while beyond them the speed of air is less and the pressure great.

2. To demonstrate air pressure.

Take a round bottomed flask and fit its mouth with a rubber cork with a hole in it. Pass a glass tube through the hole. Add water to the flask and boil it vigorously. Invert the flask and let the free end of the glass tube be immersed in a vessel containing water. As the steam in the flask will condense, so the water from the vessel will rush inside the flask in the form of a fountain. The effect can be made spectacular if a little ammonium hydroxide be added to the water in the vessel and a little phenolphthalein to the water in the flask.

3. Compressed air.

Take a bottle of a large size and fit its mouth with a rubber cork provided with two holes. Pass bent glass tubes through these holes and let the end of one of the tubes remain a few inches above the bottom of the bottle. This tube can be connected to a water tap through a rubber tube having a pinch cock attached to it. The other tube remains far above the bottom of the bottle and serves as an exit ; attach a rubber tube to the exit tube and fix a pinch cock to the rubber tube.

Keep the pinch cock of the exit tube closed and let water flow into the bottle through the inlet tube. When the bottle is half filled with water, close the stop-cock of the inlet tube. Now open the other pinch-cock. The air will come out under pressure through the outlet tube having a jet attached to it. You can suspend a ping-pong ball on this jet of air for a few seconds.

4. Experiment on diffusion.

Connect a porous pot to a U-tube containing mercury. Take a cell and an electric bell and connect them as shown in fig. 36. The free end of the wire connected to the cell is immersed in mercury, and the free end of the other wire connected to the bell is kept a little above the surface of mercury. Place a jar containing hydrogen over the porous pot. The light hydrogen molecules moving more quickly than the air molecules diffuse more rapidly in the jar than air molecules diffuse out. The pressure inside the pot will rise ; consequently the level of mercury will rise and the electrical circuit will be completed and the bell will ring. What is your conclusion from this experiment ?

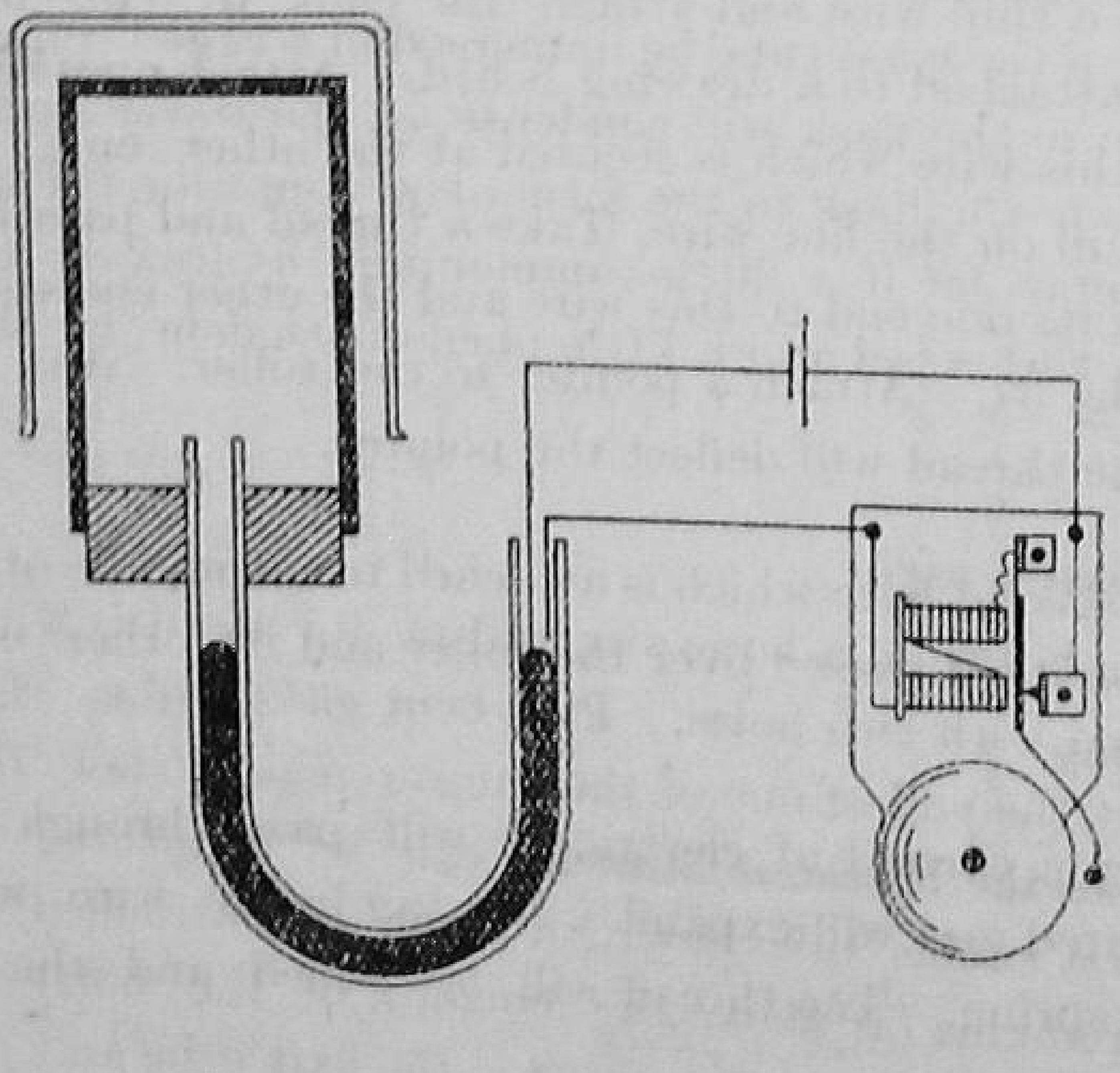


Fig. 36.

Current Electricity.

A device for detecting an electric current (Galvanometer).

An electric current can be detected with a device known as a galvanometer.

1. How to construct a galvanometer ?

(a) Take a razor blade and magnetise it strongly by rubbing a magnet over it several times, using the method of single touch.

Now make a loop of wire using bell wire wide enough to hold the razor blade. The loop should not have less than 40 or 50 turns, and the two ends of the wire should be made clean with a sand paper. Suspend the loop from a stand and suspend the razor blade inside the loop. The free ends of the coil can be connected to two binding posts. Pass electricity through the coil, and the blade will be deflected. Can you explain why the razor blade is deflected ?

(b) *Construction of hot wire ammeter.*

It is an instrument which is used to measure small alternating currents.

Take a thin wire and attach its ends to two binding screws which are attached to a drawing board. Attach another wire to the middle of this wire which is secured at the other end, and exerts a constant pull on the fine wire. Take a thread and pass it over a roller and attach its one end to this wire and the other end to a spring as shown in fig. 37. Attach a pointer to the roller. Any small movement of the thread will deflect the pointer.

The second wire which is attached to the middle of the stretched wire can be itself passed over the roller and its other end connected to the spring.

When a current of electricity will pass through the wire, it will be heated and will expand. The sag in the wire will be taken up by the spring. The thread will be pulled and the pointer will move over the scale.

As the heat produced in the wire is independent of the

direction of current of electricity, so this arrangement can be used for the measurement of alternating currents.

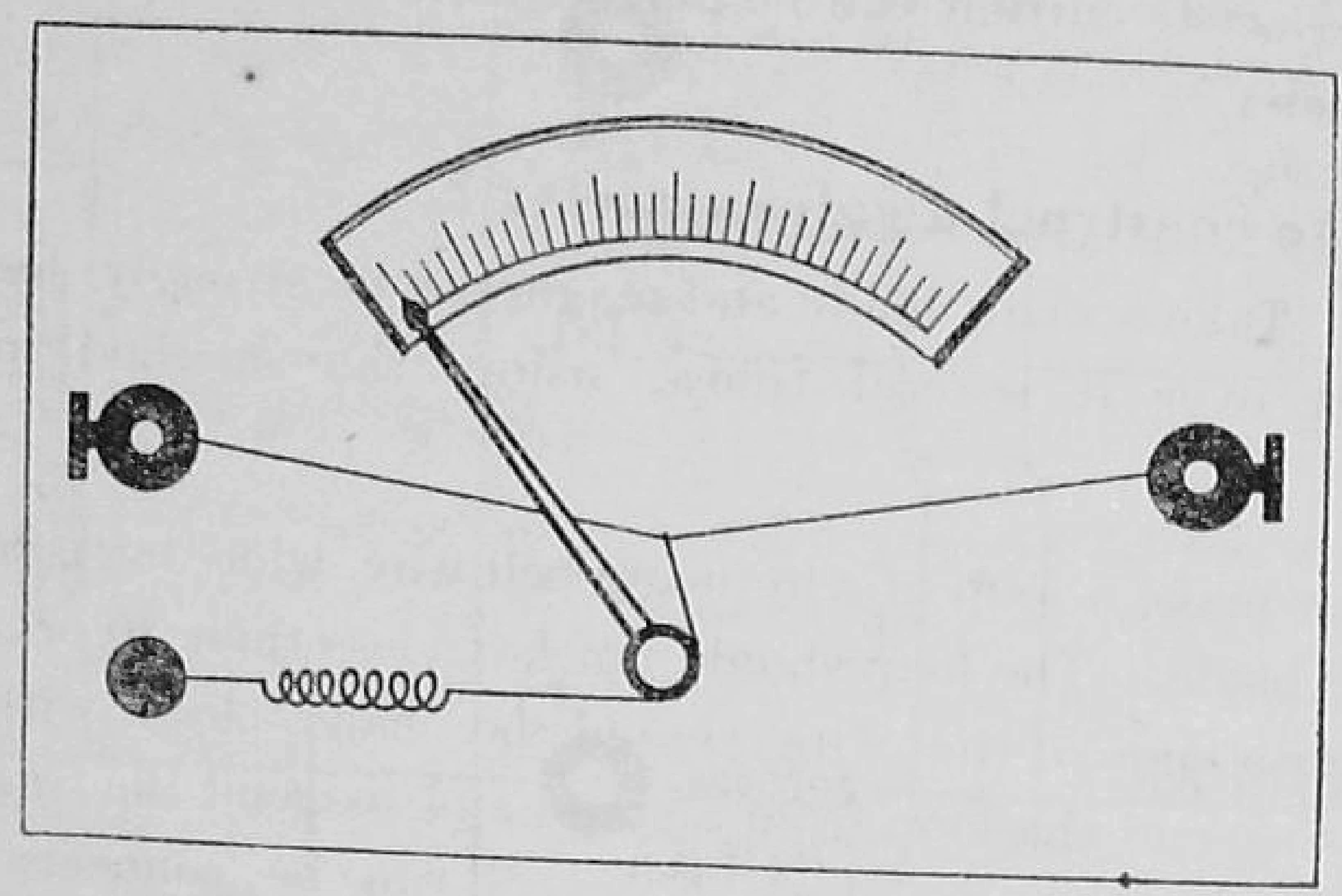


Fig. 37.

2. Burglar alarm.

(a) Take a piece of wood, and fasten a metallic strip M to it by means of two screws, and turn up the ends of the metallic strip as shown in fig. 38. Make a lever L of metal and bend out its one end so that it does not touch the strip M and the screws that are under it. Pivot the lever in the middle with a screw and a washer. Make a hole in the lower end of the lever and attach to it a spring and a string, as shown in fig. 38. Fasten the other end of the spring to a screw B. Take a cell and an electric bell and connect them, as shown in the diagram. Connect one wire leading from the bell to M, and the other wire leading from the cell to the screw B.

In order to set the alarm, fix this appliance in a convenient place, and carry the string across the room and fasten it to some point. Adjust the lever so that it remains halfway between the two ends of the metal strip. If the string be disturbed, the lever will come in contact with one end of the metallic strip causing the circuit to be completed and thereby setting the bell to ring. If possible fasten the free end of the string to a hook attached to

the panel of a window which is closed so that when it is opened, the alarm is set working.

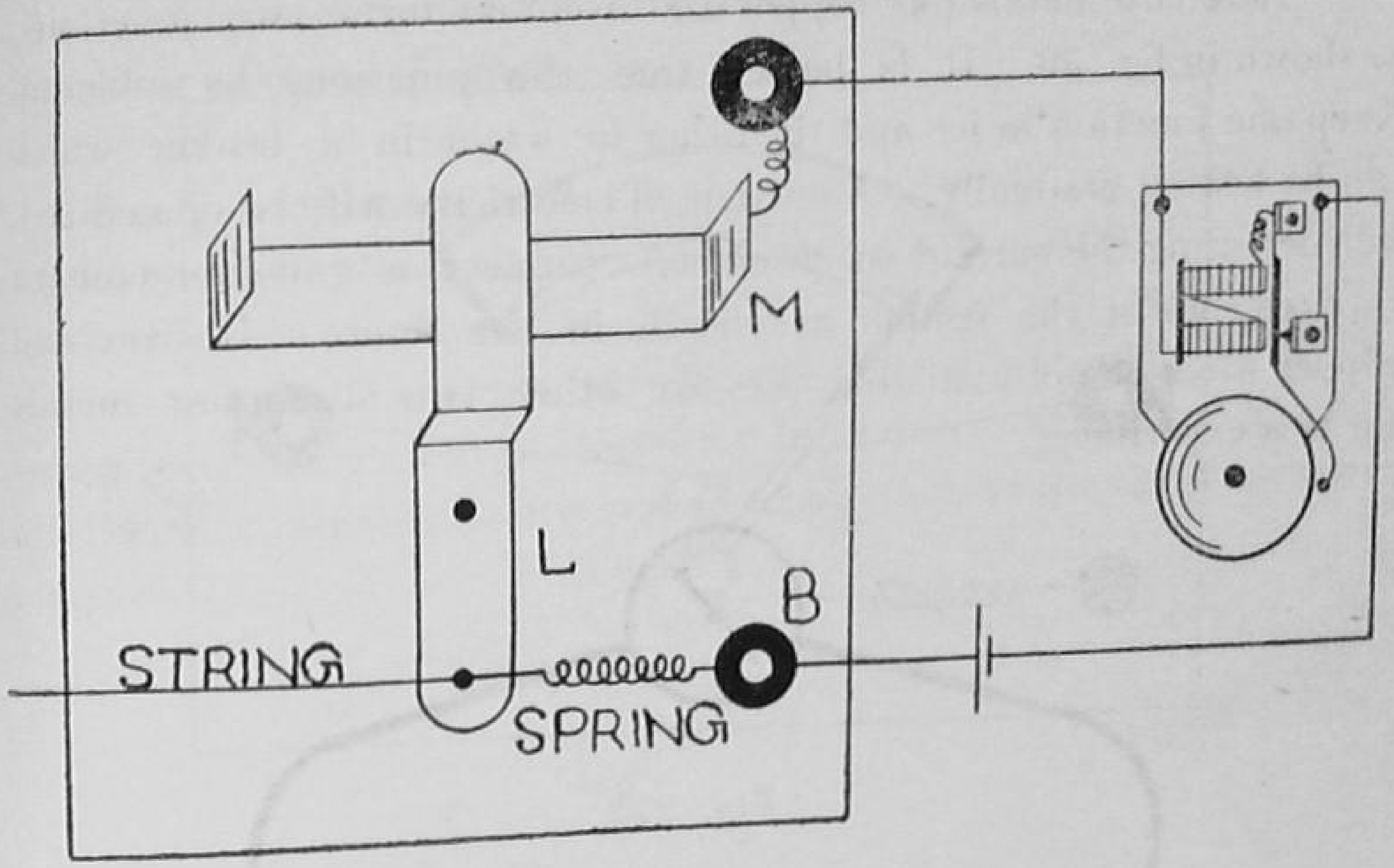


Fig. 38.

(b) The above experiment can be modified. Fix the appliance mentioned above in (a) to the inside of the bottom of a box, and the electric bell to the inside of the lid of the box. The spring joined to B can be so arranged that the lever does not touch either of the ends of the metallic strip M so long as the box is closed. But when the lid is opened, the lever should come in contact with either of the ends of the strip M, and the alarm is set working.

3. Determination of the wattage of an electric lamp or any other electric device.

Try to have a lamp of 5 or 6 volts whose wattage is to be determined, and connect it in series with an ammeter and a battery. Place a voltmeter in parallel with the lamp. Note the readings on both the instruments. Use a switch to control the circuit.

Watts = Volts × amperes.

N. B. You can determine in the same way, the wattage of a lamp of 110 or 120 volts. But you have to use meters of high range, which are costly.

4. Thermo-electric currents.

(a) *To set up a thermo-couple.*

Take two metals like copper and iron and form two junctions, as shown in fig. 39. It is better that the junctions be soldered. Keep one junction in ice and the other in water in a beaker which can be heated gradually. A current of electricity will be generated. For detecting the current so produced, connect a galvanometer to the free ends of the couple as shown in the figure. If iron and copper wires be not available, use any other two dissimilar metals for this experiment.

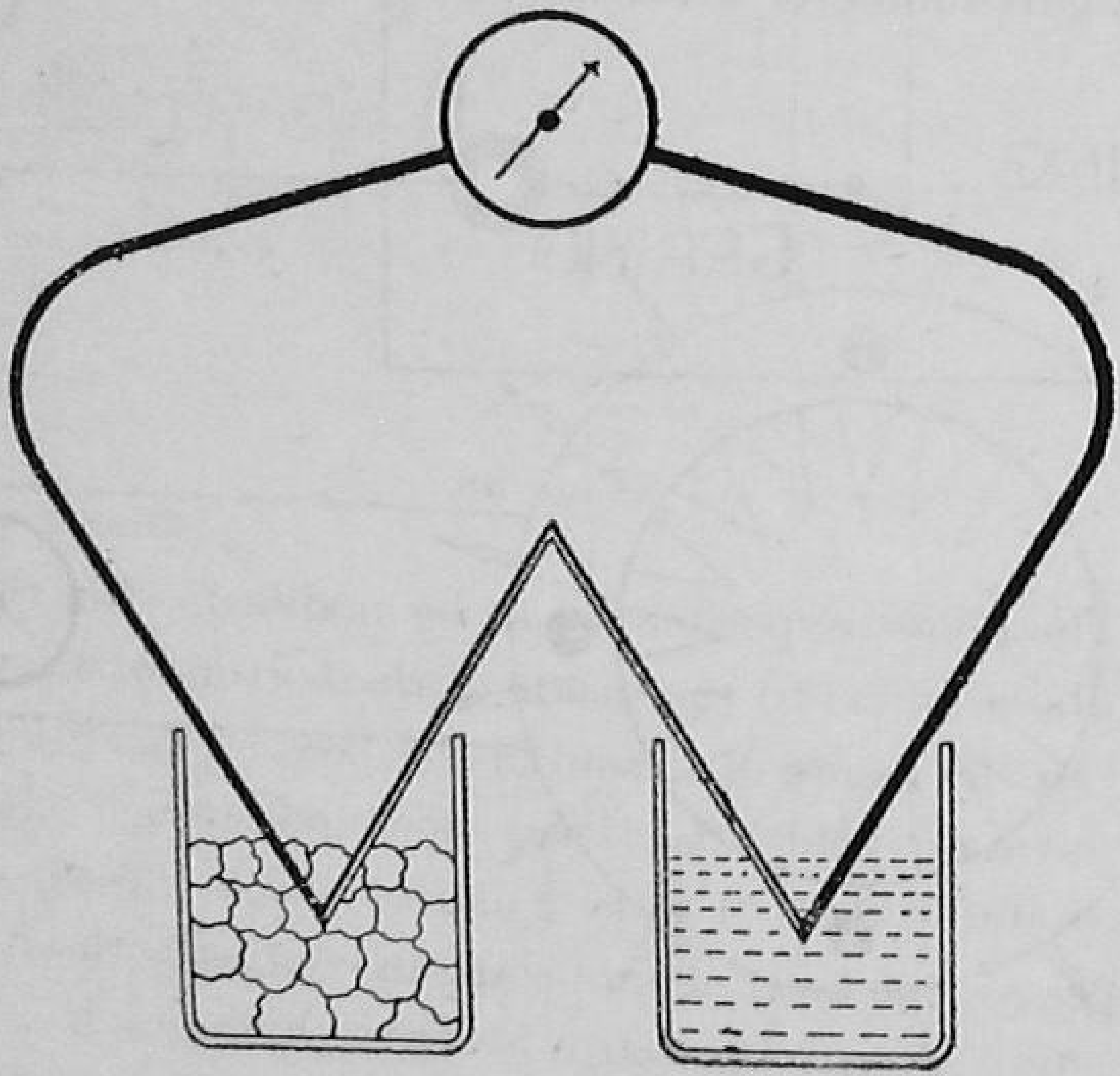


Fig. 39.

(b) *Consruction of a thermopile.*

Cut several pieces of iron and an equal number of copper wires. Twist each iron wire firmly with a copper wire, preferably solder the ends.

Make two wooden rings each about 4½ inches in diameter. Place the wires on one of the rings, and place the second ring on top of the first. Join the two rings by means of screws as shown in fig. 40. Be careful that the inner junctions of the wires do not touch each other. Support the rings so joined on a tripod stand. Connect the

two ends of the thermopile to two binding posts. Heat the inner junctions by a burner. A current of electricity will be produced which can be detected by a galvanometer or a telephone receiver, attached to the binding posts of the thermopile.

You can make a still simpler arrangement by taking two straight pieces of wood and securing the couples with their help. Heat with a few burners the junctions on one side whereas the junctions on the other side of the pieces of wood are kept at room temperature. A current of electricity is produced which can be detected with a galvanometer attached to the ends of the thermopile so constructed.

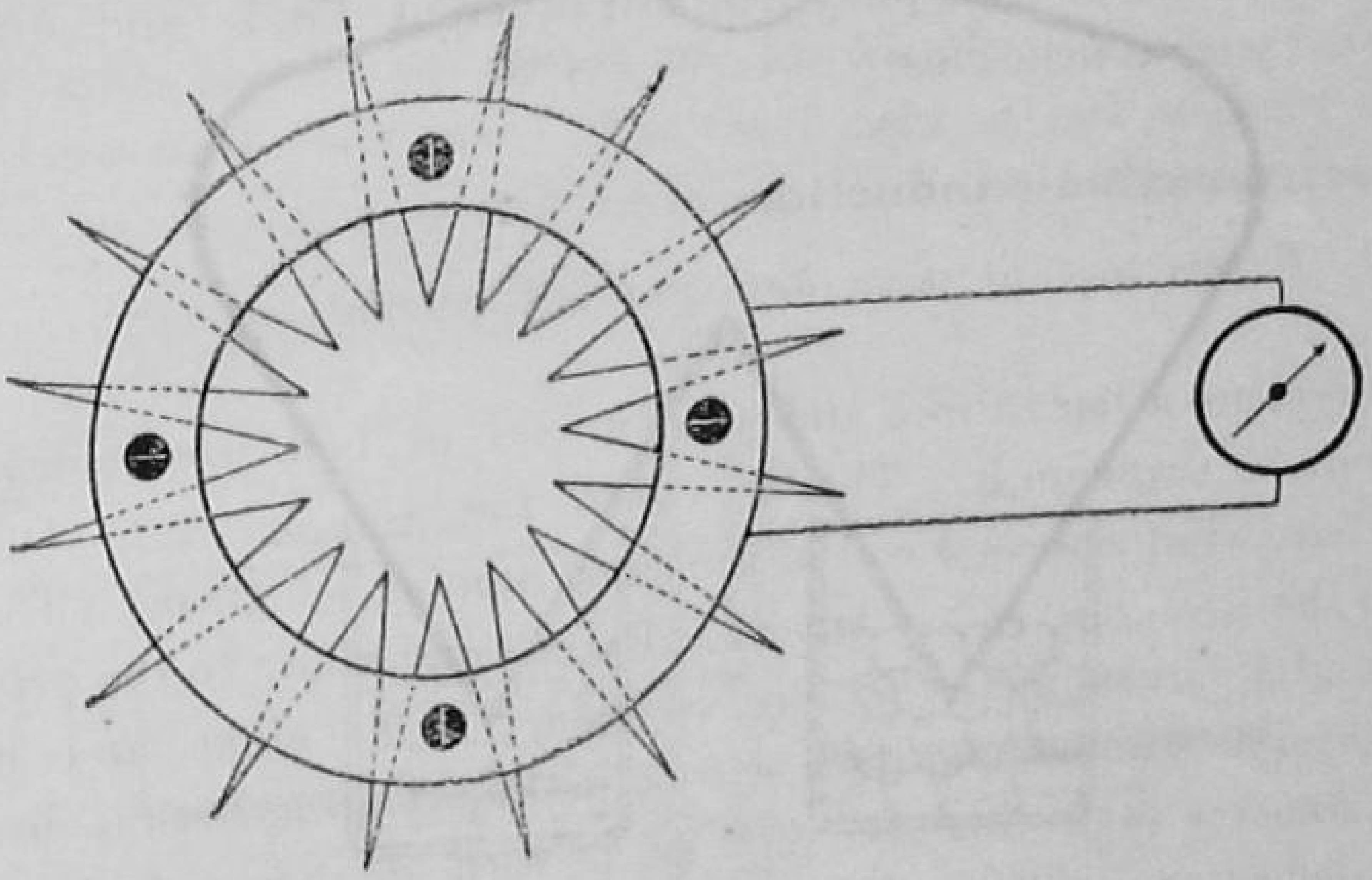


Fig. 40.

5. To distinguish between alternating current and direct current.

(a) Take a centre-zero ammeter and connect it to a dry cell through a resistance. The needle will be deflected to one side, and remain stationary. Now replace the dry cell with a hand magneto. Work the hand magneto and note the movement of the needle which will fluctuate to either side of the centre zero. Draw your conclusions. The hand magneto gives alternating current. The dry cell gives direct current.

(b) *To find the positive pole of a cell by a potato.*

Cut a potato and connect two wires to the poles of a cell. Place the free ends of the wires on the cut slice of the potato without making them touch each other. There will be produced blue colour near the end joined to the positive pole of the cell.

6. To test the ripeness of a fruit.

Take a strip of copper and a strip of zinc and solder a copper wire to each one of them. Connect the free ends of the wires to a galvanometer or voltmeter. Now insert the copper and zinc strips in an orange or a lemon. A voltaic cell will be set up due to the presence of acid in the fruit. The needle of the galvanometer will be deflected. Test the voltage set up with the help of a voltmeter. Try the experiment with juicy fruits of different kinds and quality, and draw your conclusions.

7. Electromagnetic induction.

(a) *Experiment to show how induced currents of electricity are produced.*

Procure a bar of iron and wind a coil of bell wire consisting of about 30 turns on it. This is called the *primary coil.* On the same bar, wind a second coil of the same number of turns. This is called the *secondary coil.* Attach a dry cell and a key to the primary coil, and a galvanometer to the secondary coil. Make and break the primary circuit, and there will be produced a deflection in the galvanometer each time the key is pressed or released, but the two deflections will be in opposite directions. The currents so produced in the secondary coil are called induced currents of electricity.

(b) *Electric motor.*

An electric motor converts electrical energy into mechanical energy. It consists of (a) field magnet (b) armature (c) commutator and (d) carbon brushes.

How to make a toy motor?

(1) For making the *armature,* take a long cork and stick a pin in each of its ends, which should be as nearly central as possible.

The pins form the shaft of the motor. Take some fine magnet wire and wind it on the cork, as shown in fig. 41. Wind an equal number of turns on each side of the two pins. The wire can be attached firmly to the cork by means of thread. Bend tne two free ends at right angles and parallel to the shaft and bare the ends of the wire and clean them with a sand paper.

(2) Take two pins and stick them in a cork so that these cross each other. Prepare another cork in the same way. These corks will serve as *bearings*.

(3) Now place the armature in the bearings and then place two bar magnets on either side of the armature as shown in fig. 41. The magnets should be placed on blocks of wood and should be quite close to the armature. The north pole of one magnet should be next to the armature and the south pole of the other opposite.

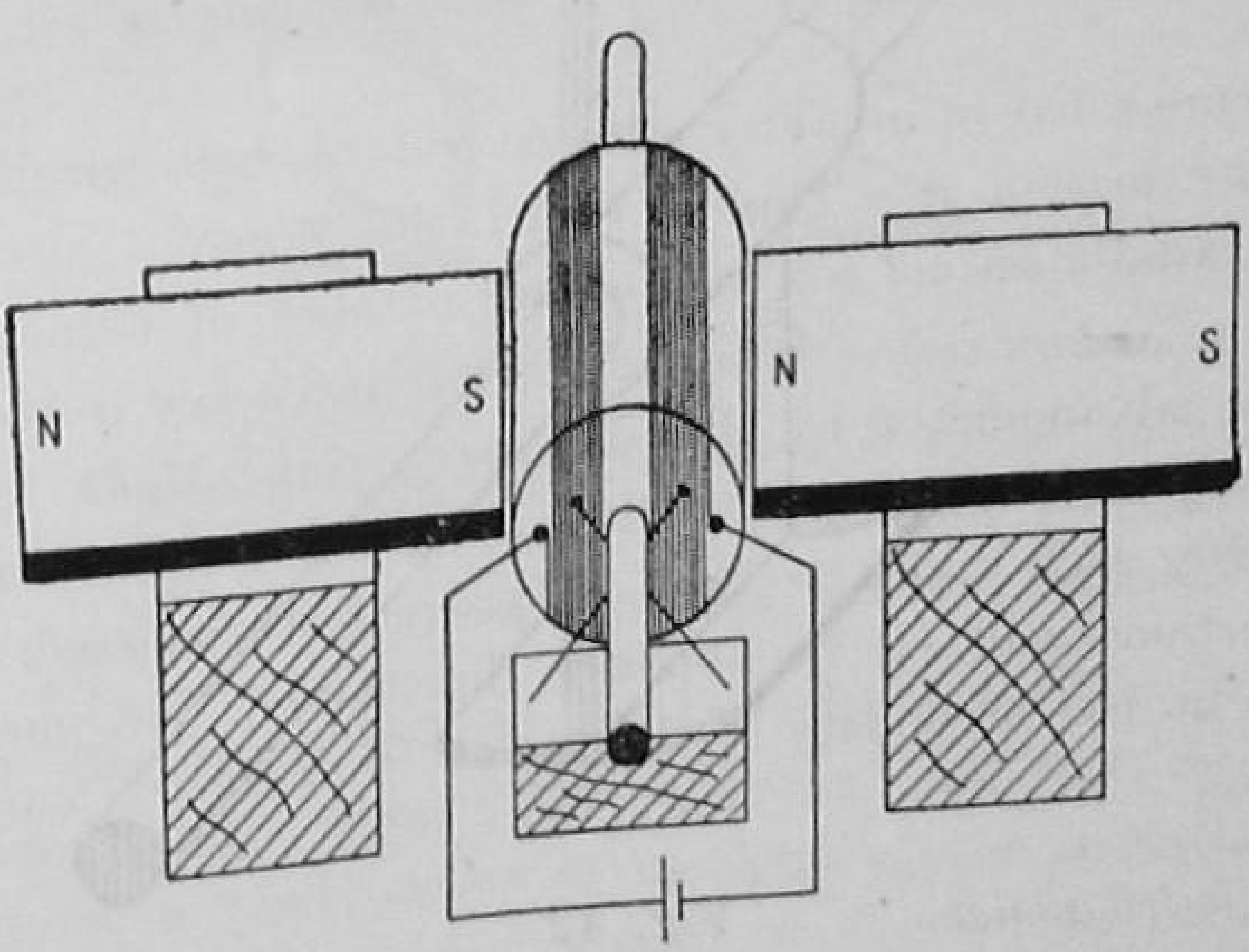


Fig. 41.

(4) Take a dry cell and connect its terminals to two long wires. Holding these wires in hands, make them touch the two ends of the wire on the armature. In the beginning, start the armature moving and then make the ends of the wires connected to the cell to come in contact with the armature as it revolves.

The motor will be found to be working. Explain the principle of the motor.

(c) *Second method to set up the model of a motor.*

(1) A motor consists of a *field* and an *armature*. Let us first of all construct the *armature*. For this purpose, take a tin plate and from it cut two strips, and mark a line across the centre of each strip. Bend each strip into the shape shown in fig. 42. with a small bend in the centre which can be made by bending each strip over a metallic rod. Solder the two halves of the armature together. Pass a needle through the central hole to make a shaft.

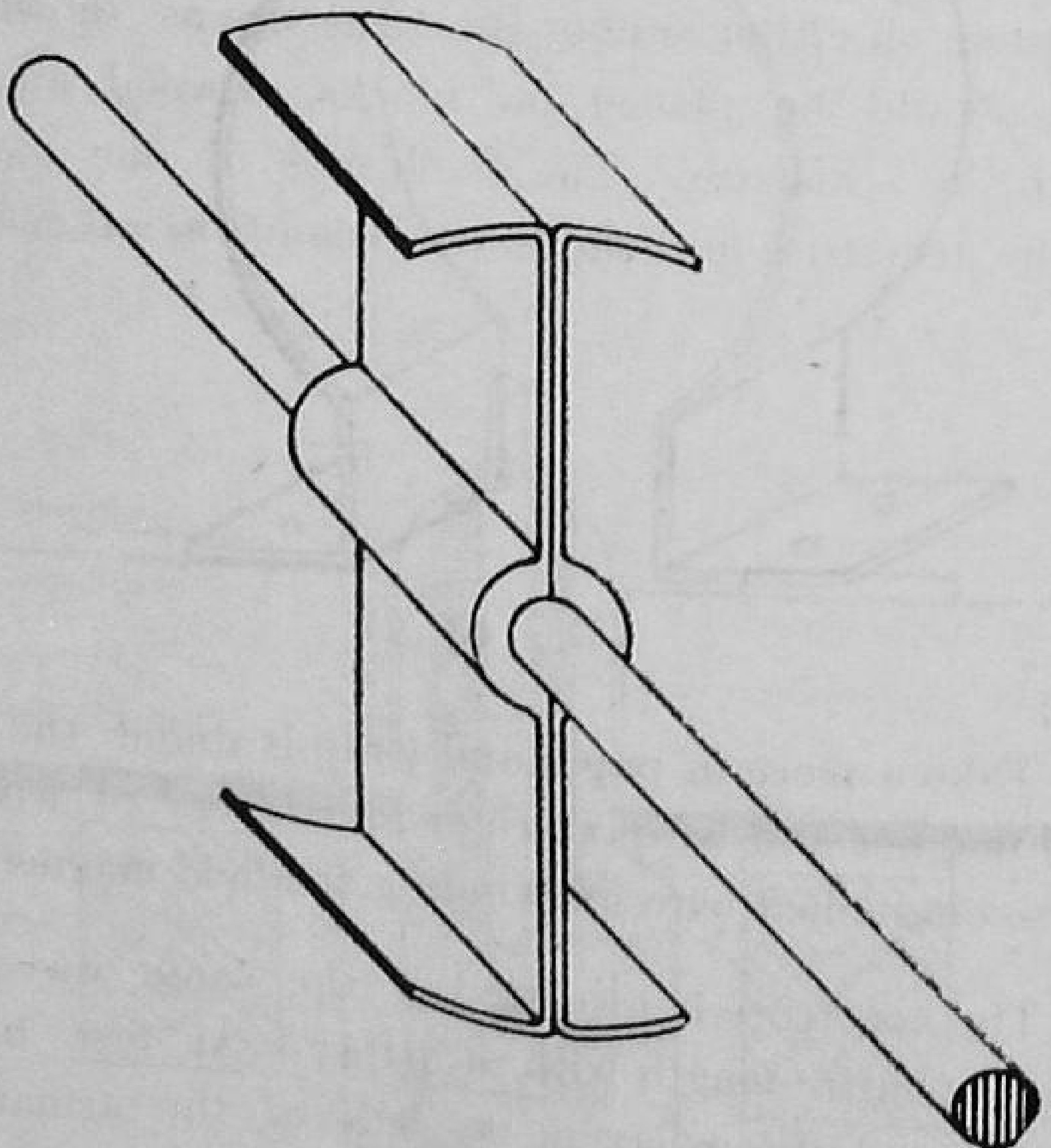
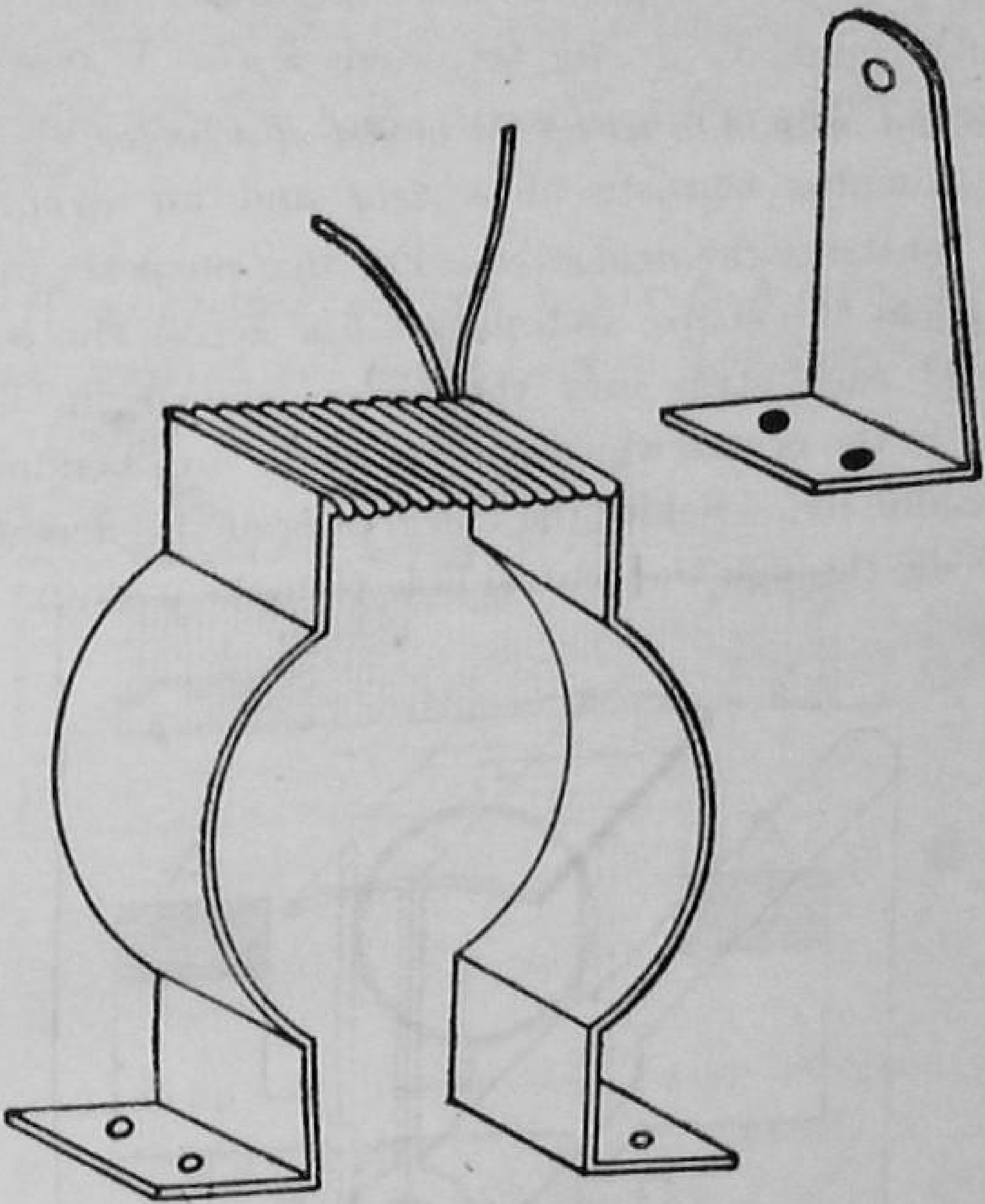


Fig. 42.

(2) For making a *field* cut a strip of tin into the shape shown in fig. 43 (a). Bore holes in the feet of the field magnet and fasten it to the base by means of screws passing through the holes.

(3) For making *bearings* to hold the shaft, cut from the sheet two pieces of the shape shown in fig. 43 (b). Make a hole in each

to hold the shaft and fix the bearings to the base.



(b)

Fig. 43 (a)

(4) Take a piece of paper and wrap it round the flat portion of the field magnet and wrap three or four layers of wire round the paper. Use enamelled wire for winding the field magnet.

(5) The armature is insulated in the same way as the field by covering its entire length with a paper. At first by using one end of the wire, wind four layers on half of the armature and tie this end down with a piece of thread, and wind in the same way the other half of the armature.

(6) Bare the ends of the armature wire and connect them to the segments of the commutator attached to the shaft, which are insulated from it. Next make the brushes which can be made out of nails.

Connect one end of the field winding to one of the brushes B,

and one pole of a battery of two or three dry cells to the other brush B through the terminal T and connect the other end of the field to the second terminal T. To the terminals T and T connect the poles of the battery. The motor so constructed is series wound as shown in fig. 44.

In the diagram A, A stand for the armature, T, T for the terminals to be connected to the poles of the battery, and B, B for the brushes.

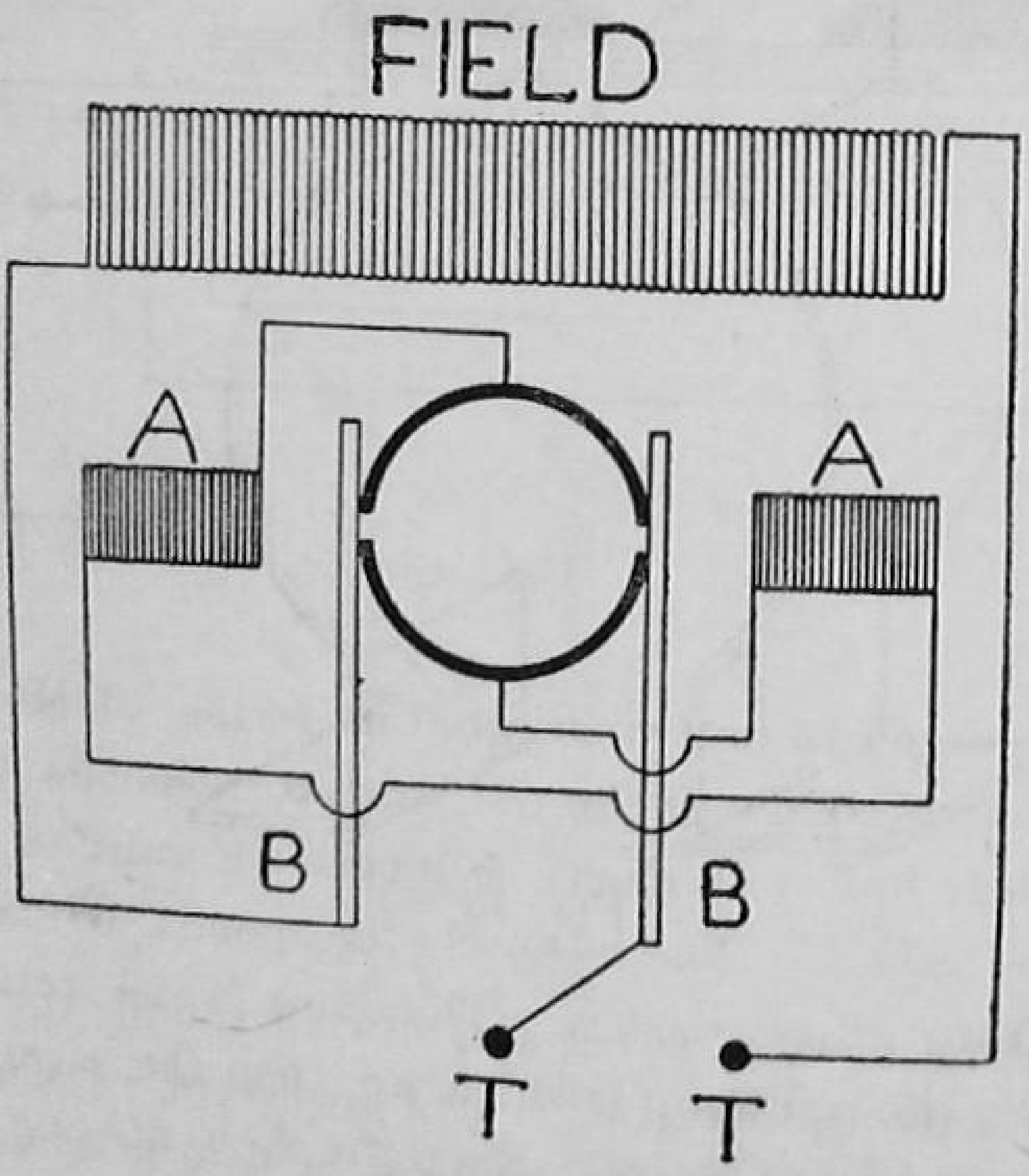


Fig. 44.

8. Sending a message by means of light signals.

Take a base board of wood, and fix on it two small bulb holders for holding torch bulbs. Fit up a red bulb in one holder and a clear bulb in the other. If a bulb holder be not available, take a thick stout wire of some metal and twist it round the case of a thermometer so as to form a coil of two or three turns. Fix it to the base board. Solder a wire to the lower metal end of each bulb. Put a red bulb in one holder and a clear bulb in the other holder prepared in the same way. As the screw cap of each bulb touches the holder, so attach one end of each bulb holder to one

terminal of the two way key, as shown in fig. 45. Connect the wire soldered to the lower metal end of each bulb to the positive pole of the battery, and connect the common terminal of the key to the negative terminal of the battery. The two-way key should be of the spring type.

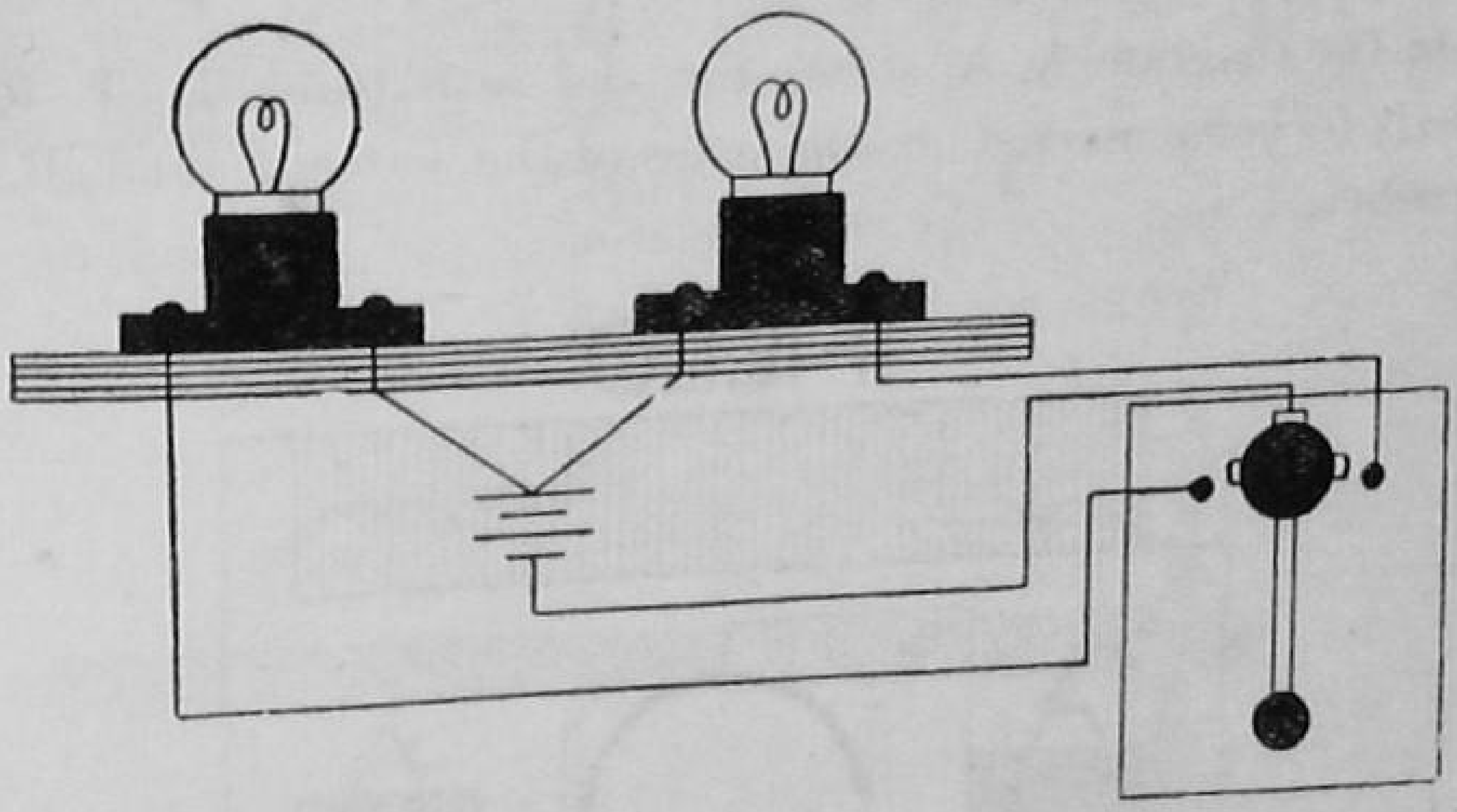


Fig. 45.

The message can be transmitted in terms of Morse code. Let us suppose that the glow of the red lamp corresponds to a dot and that of the clear bulb to a dash. Suppose we want to transmit the distress signal 'S.O.S.' The letter S corresponds to three dots and the letter O to three dashes. Therefore while transmitting this message, make the red lamp flash thrice, then the clear lamp thrice and again the red lamp thrice. Keep the key at one place of the room and the base board on which the bulbs are fixed at another place. Use long wires to connect the two stations.

9. To show the effect of temperature on resistance.

Connect a 6 volt battery, a 6 volt lamp and nichrome wire wrapped on a piece of asbestos, in series. The lamp will burn faintly. Heat the nichrome wire with a burner, the resistance of the wire will increase and the lamp will go out. Cool the wire and the lamp will light up again. The resistance of the wire increases on heating, and decreases on cooling. What will happen to current in each case ?

10. To test the steadiness of one's hand.

(a) Take a metallic rod which is well cleaned, and support it by means of a stand. Connect the pole of a battery of 2 or 3 cells to one end of the rod and attach the other pole to one terminal of a torch bulb. Attach a long flexible wire to the second terminal of the lamp, as shown in fig. 46 and to the free end of the flexible wire attach a metal ring of a diameter slightly larger than that of the rod. Try to pass the ring through the rod. Whenever the hand becomes unsteady, the ring will touch the rod and the lamp will light up. Why should the lamp glow ?

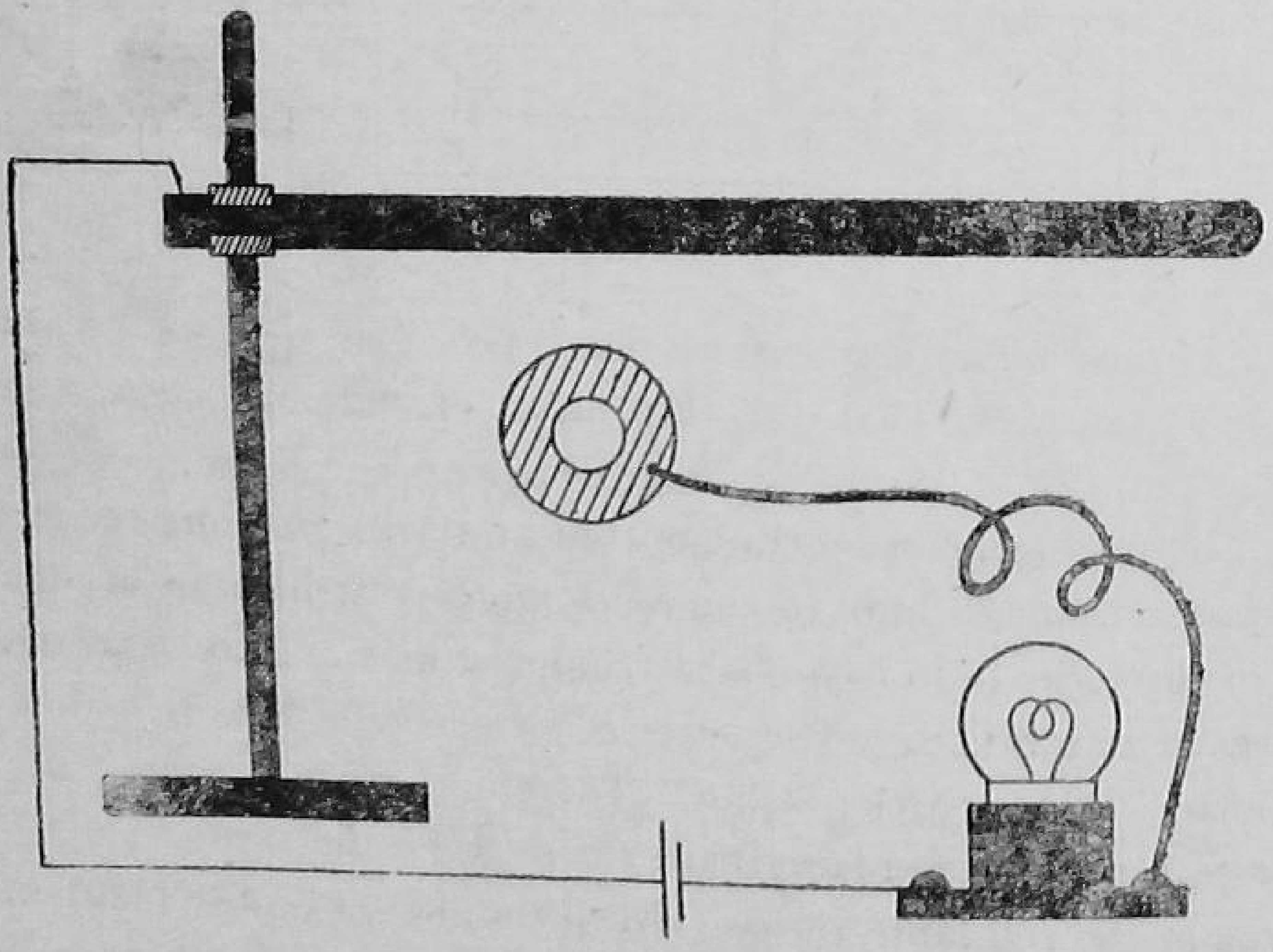


Fig. 46.

(b) There is another way by which the same test can be carried out. Take a wooden piece, and fix two bars of metal to it with a piece of glass in between them. Join the bars at one end, as shown in fig. 47. Take two cells and connect them in series, and connect one terminal of the battery to one of the bars and the other terminal to a torch bulb, as in the diagram. Attach a flexible wire to the other terminal of the bulb and join the free end of the flexible wire to a pointed metal rod. Holding the pointer in the hand, try to move it over the piece of glass which is set between the

two bars of metal. Whenever the hand becomes unsteady, the pointer will come in contact with either bar and the lamp will be lighted up.

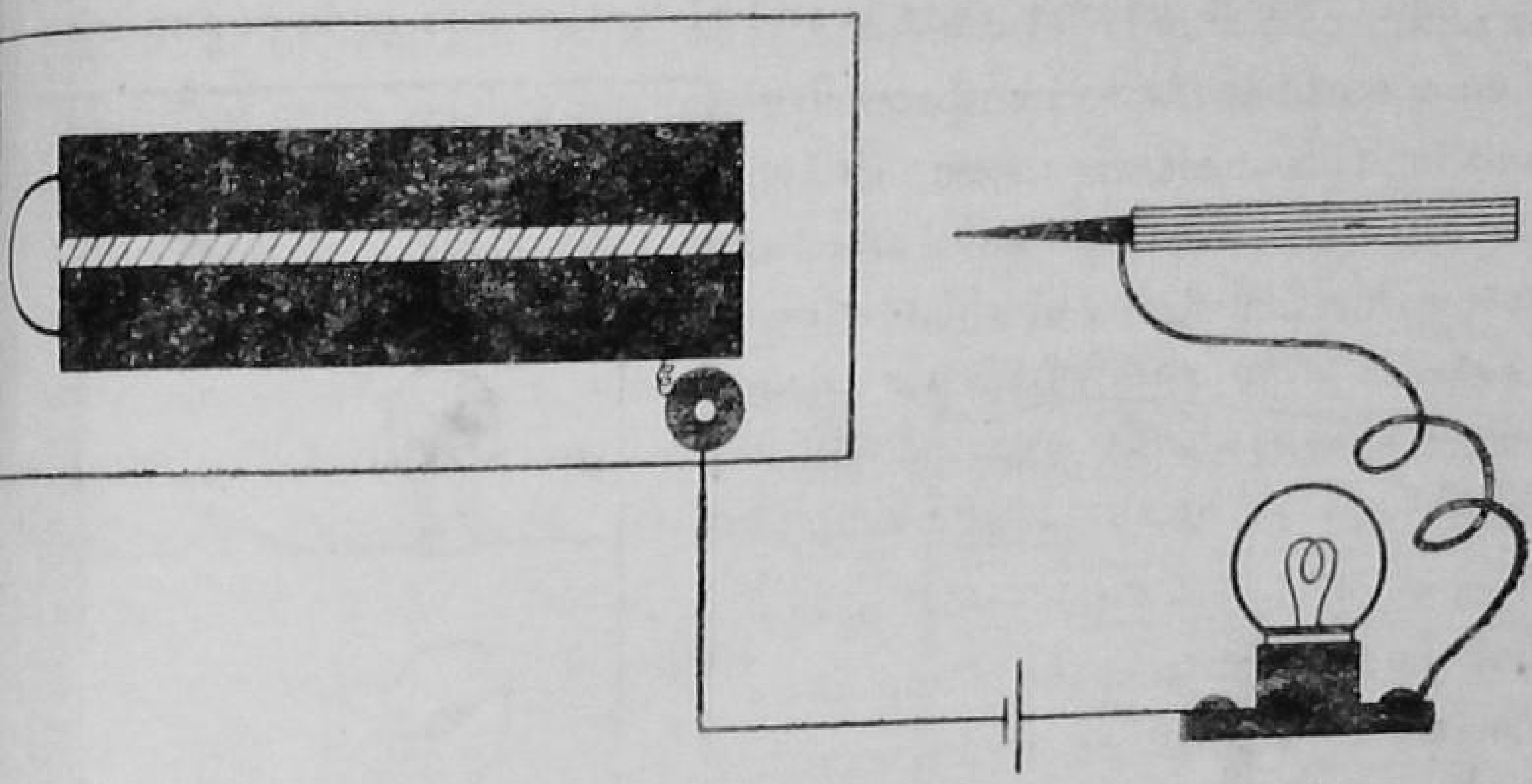


Fig. 47.

(c) There is another way to test one's nervousness. Take a metal plate, and make in it rows of holes of different sizes. Keep the plate inclined. Connect the metal plate, a cell, a torch bulb, and a metallic pointed rod in series. Holding the pointer in hand, try to pass it through differen rows of holes. Whenever the hand becomes unsteady, the pointer will touch the metal plate and there will be light in the bulb.

11. To set up a storage cell.

Take a glass vessel and put in it dilute sulphuric acid, and immerse in the acid two plates of lead. Connect a battery to the lead plates for some time. Remove the battery, and connect an electric bell to the lead strips. The bell will ring. During the first stage the cell is *charged*, and in the second stage it is *discharged*.

Describe the chemical actions that take place in the two stages.

Study the construction of a spoiled lead storage cell after taking it to pieces.

12. To set up the model of electric installation in a house.

(a) Take a wooden board and fix on it a number of lamp holders, and fix bulbs in them. Connect one terminal of each lamp

holder to the wire AB, and the other terminal of each to a separate switch. Connect the second terminal of each switch to the wire CD, and connect binding posts E and H to the free ends of the wires. Take a battery of two or three dry cells and connect its poles to E and H through a key (main switch) and a fuse wire (main fuse) as shown in fig. 48. Close the main switch as well as the other switches, there will be light in the lamps. Throw off one of the switches but not the main switch, the lamp connected to it will be extinguished. Study the circuit thoroughly and learn the importance of each part of the circuit. If the main fuse be blown off there will be no light in the entire circuit. The circuit fuses have been omitted, and if desired a circuit fuse can be inserted between each switch and each lamp. In the diagram, S stands for the main switch and F the main fuse.

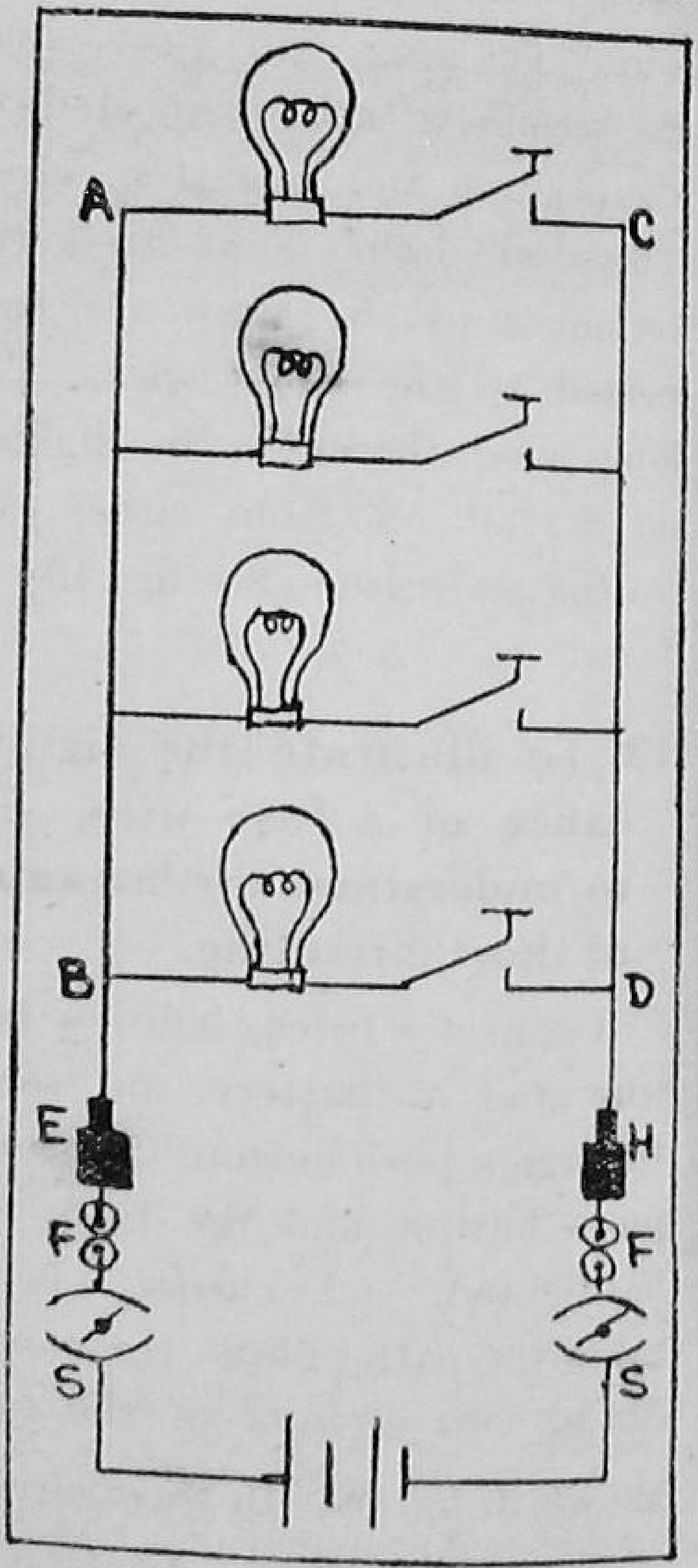


Fig. 48.

(b) *Staircase winding.*

Experiment to show how a lamp can be put on or off from either end of a staircase.

In order to fit up a lamp for a staircase, use a double switch at either end. A double switch has three terminals. Take a long rectangular piece of wood and fix at its ends two double switches. Connect a torch bulb to the middle terminals of the switch keys, and connect the poles of a cell to the other two terminals of one of the switches. Connect the outer terminals of the two switches

by long wires. By turning the handle of the switch, the middle terminal at each end can be connected to the positive or negative wire. The lamp will glow when its terminals are connected to the positive and negative wires. There will be no light when the terminals of the lamp are connected to the same wire. The lamp can, therefore, be lighted on or put off from either end of the staircase. See fig. 49.

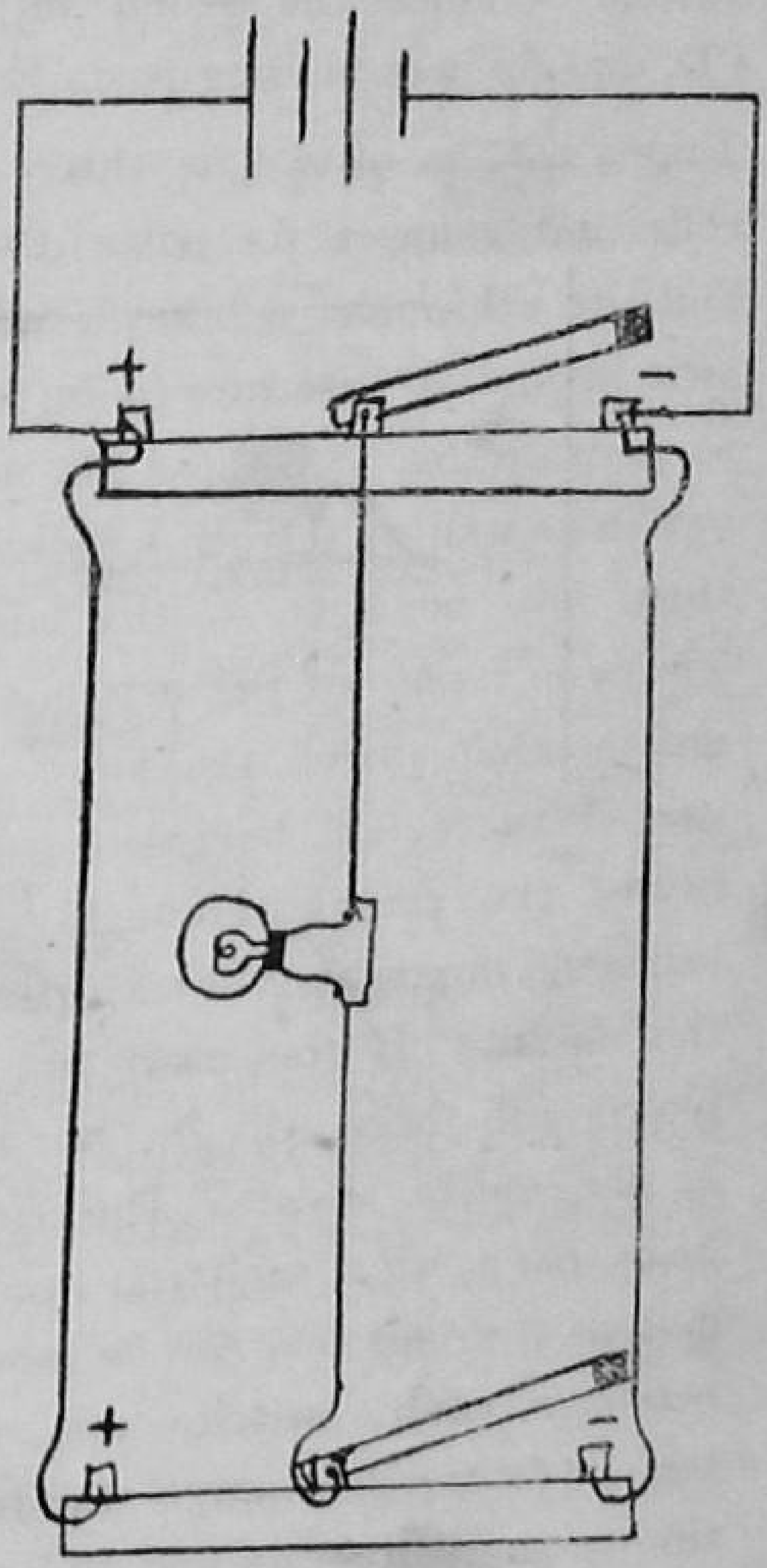


Fig. 49.

13. To illustrate the significance of a fuse wire, and to understand the meaning of short circuiting.

Connect a torch bulb, a fuse wire and a battery in series through a push button. Press the push button and the lamp will be lighted. A current always takes the path of least resistance. Set up two circuits of the type shown in fig. 50. In these circuits the wires are naked. In the first diagram, the wires coming from the cell touch each other near the push button, and the current continues to flow through the lamp which remains lighted all the time. The push botton in this case is ineffective.

In the second diagram, the lamp will not be lighted at all. The current will go back to the cell without going through the electric bulb when the push button will be pressed. In the above two cases, there is a *short circuit*, as the current follows the path

of least resistance.

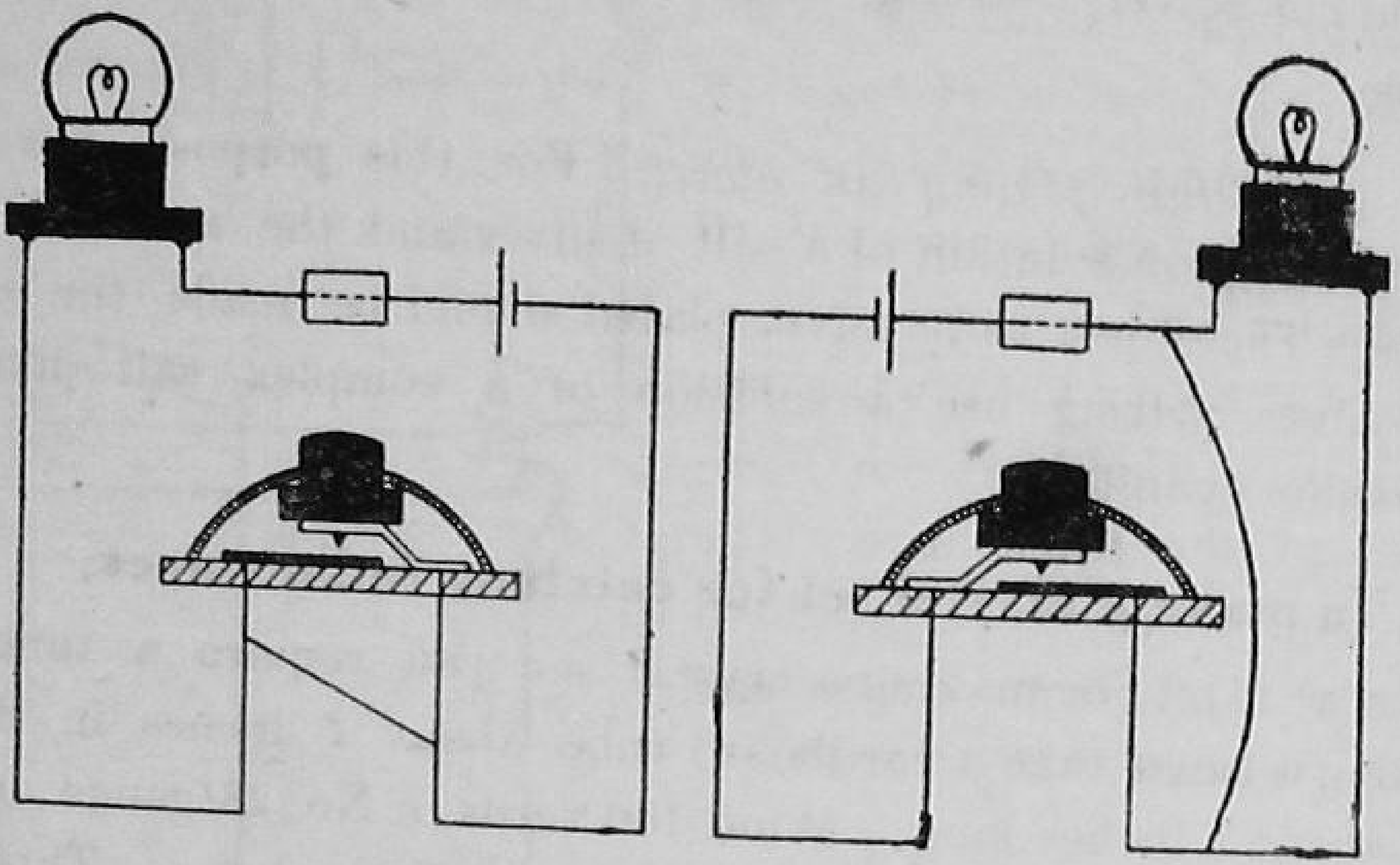


Fig. 50.

. **Electroplating.**

The object to be electroplated is made the cathode and it should be thoroughly cleaned. There should be no grease present on its surface. The electrolyte is a solution of the metal to be deposited on the object and the anode is a rod of the metal to be deposited.

(1) *Nickel plating.* Dissolve one part of nickel sulphate in twenty parts of water and add one part of sodium bisulphate. Pour it in a trough. Take a battery of several cells and attach the object to be electroplated to the negative pole of the battery. Before attaching the object, it should be thoroughly cleaned by treating it with nitric acid and then with sand paper. Attach nickel wire to the positive pole of the battery and immerse it in the electrolyte. The circuit should contain a key. Close the key and let the current flow for some time. Nickel will be deposited on the object. When it will be removed, it will have a dull white colour, and when it will be polished with a wheel which is set revolving, the nickel will acquire a bright lustre.

For depositing metal on both sides of the object, there should be a rod of nickel on its either side, and both the rods should be

connected to the positive pole of the battery. The current used should not be very strong, otherwise the metal deposited will be brittle.

(2) *Silver plating an object.* For this purpose, the electrolyte should be a solution of a salt of silver and the anode a rod of silver. The object to be silver plated should be made the cathode. For silver plating use a solution of a complex salt like silver potassium cyanide.

15. To make a crystal set for catching radio waves.

(a) (1) For making a crystal set you require a tuner. For making a tuner take a cardboard tube about 2 inches in diameter and about 7 inches long. Wind 100 turns of No. 28 gauge insulated copper wire so that the turns form a single layer. This is the *inductor*.

Take a variable condenser of capacity .00035 microfarad consisting of stationary and movable plates. Connect one end of the inductor to the rotary plate terminal of the condenser, and the other end of the coil to the stationary plate terminal. This combination is the *tuner*.

(2) For making a set you require *earphones.* Usually, two of these phones are connected in series and are held in place by a metal band that fits over the head.

Fig. 51, shows an arrangement containing an aerial-ground system connected to the tuner and the headphones which will not work, in the absence of a crystal.

The radio waves strike the aerial and set up in it oscillatory currents which begin to flow through the receiver, but nothing will be heard in the phones, in the absence of a crystal.

(3) For overcoming this difficulty, a crystal is introduced in the circuit. There are certain crystals like *carborundum* and *galena* that have the property of allowing current to flow in one direction but not in the other. The crystal which is most commonly used as a detector is *galena.* Every spot on this crystal does not

possess the property of making uni-directional current. Therefore a fine wire is used to find sensitive spots. The wire so used is called cat-whisker.

Fig. 51 gives the complete arrangement of the crystal set. This arrangement contains a crystal in the circuit. The crystal which is most commonly used is galena, and is put in series with the phones. Move the cat-whisker from place to place, and when you find a spot when you hear a sound in the phones, leave the wire at that place. Adjust the tuning control to produce maximum loudness of signal. *Try to make your crystal set according to the above plan.* Remember that a crystal set can only catch a local station.

N. B. You can avoid the use of the condenser by having a variable coil for catching a local station. For this purpose, the condenser is removed, and insulation is removed from the upper surface of the turns of coil and a movable handle of metal is made to touch the naked surface of the turns of the coil. The necessary connections are transferred to the handle, all the other connections remaining the same.

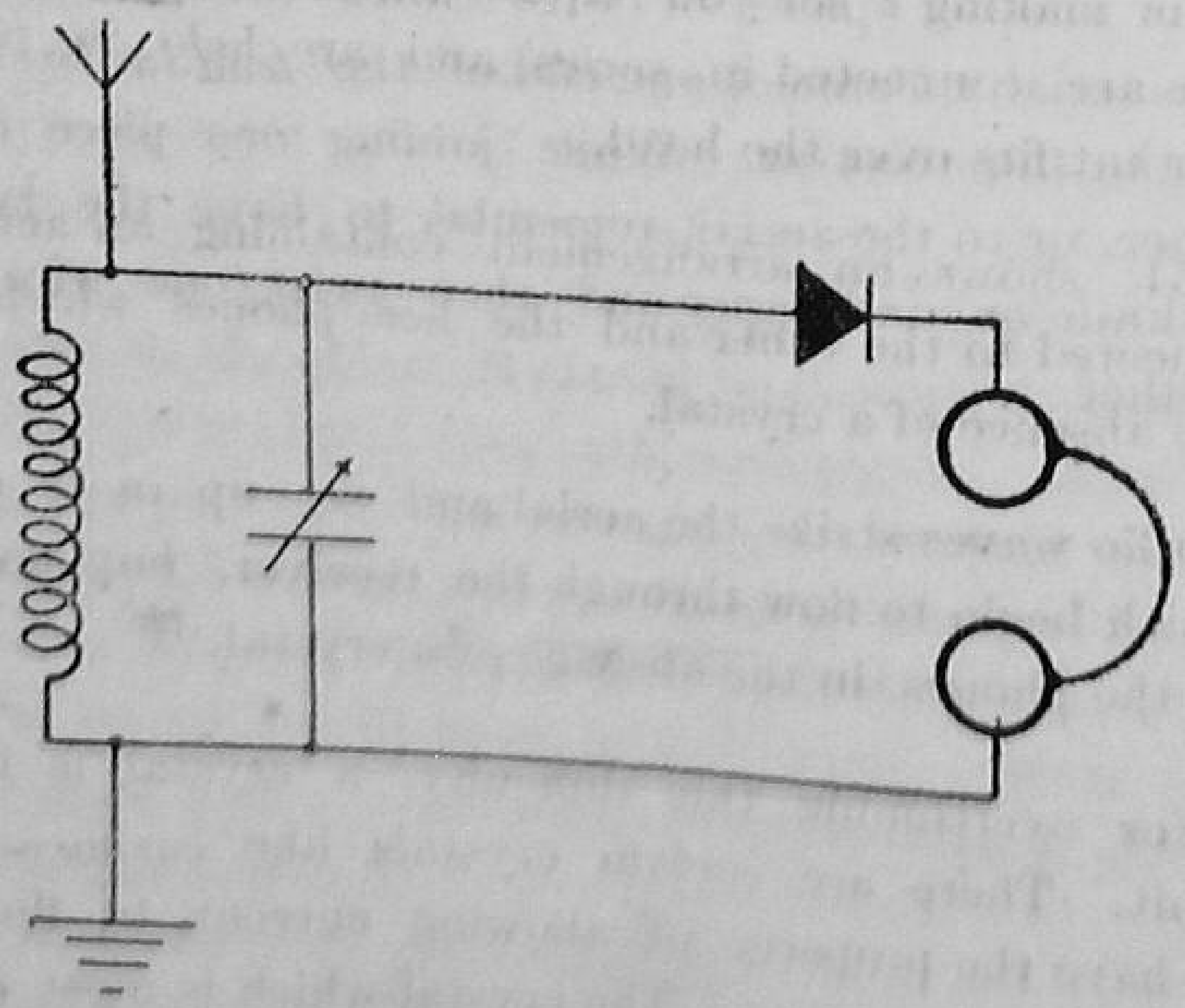


Fig. 51.

(b) *Improved crystal receiver.*

This set will tune sharper as it uses an *antenna coupler.* We will, therefore, be able to keep out the unwanted stations. For this purpose we have to use a *transformer.* The tuning coil of the receiver is made the secondary of the transformer and the primary is connected to the aerial ground system. Such a transformer is called the *antenna coupler.* For making such a coupler, wind upon the same tube on which you have your tuner coil additional 15 or 20 turns of the same wire. Separate the two windings about 1/8th inch. Connect the aerial to one terminal of the primary and the ground to the other. Try to reverse these connections to find out if you can find better results.

Try to make the improved set, if you have finished the previous arrangement.

(c) *Aerial.*

For installing an aerial, take a wire about 80 ft. long of No. 12 or 14 gauge copper. It should be raised above the ground and supported on two wooden poles and insulators should be attached to both ends of the wire to prevent the leakage of small currents. An insulator used for this purpose may be porcelain or rubber or bake-lite. There is another piece of wire called the *lead-in* which is similar to the aerial. Connect one end of the *lead-in* to the aerial and the other to the receiver. While joining one piece of *lead-in* wire to another, or to the aerial, remember to have the two pieces clean with a knife or sand paper and then twist one wire securely around the other.

CHAPTER IV

Science clubs in other countries

Science Clubs for students of school and college age are considered the world over to be useful agencies for spreading scientific knowledge and initiating important research work among the young generation.

In the U.S.A., where science clubs are the most highly developed, there are several groups which have an elaborate system for ensuring co-operation and co-ordination among the different clubs througout the country, and sometimes abroad. The Future Farmers of America, the 4-H Clubs, the Audubon Junior Clubs and the Science Clubs of America may be cited among such groups. The first two are for students specializing in agriculture, domestic science and nature study and protection. Science Clubs of America comprise about 15,000 individual clubs in all fields of science. The Central organization gives them valuable assistance in providing all sorts of materials and publications, including those of the sponsoring organization, Science Service. Annual competitive examinations, under the name of "Science Talent Search" are organized for all senior high school students or members of science clubs, in collaboration with the Westinghouse Educational Foundation. Several science scholarships are awarded each year and the winners usually distinguish themselves as scientists in later years. Another aspect of the organization is a training system for young scientists under which members of science clubs may be given specific jobs to do for scientific institutions. This is an excellent stimulus and gives the young scientists an opportunity to do field work, collect statistics, and record their findings for use by the institutions which asked to have the work done. There are numerous industrial firms which supply materials and equipment to the club members at reduced rates.

In Canada, there are similar club movements, several of which are sponsored by the federal or provincial governments, and also

competitions and exhibits. You will be interested to know that several members of science clubs have won world recognition at international exhibitions.

In European countries, the science club movement takes a different form. There are few central organizations, but many individual clubs, some of them carrying on their activities on a national, or even international, scale.

The Dutch Youth Society for the study of nature, for example, was organized over thirty years ago and has grown to be one of the most successful science clubs. In addition to the usual published activities, the club illustrated a monthly journal, calendars decorated with photographs taken by members, booklets of various sorts, and has organized several exhibitions. The influence of this group has spread beyond the Dutch borders and new contacts have been established with clubs in other European countries and several international study camps have been organized, which are attended by members of these different clubs.

It is evident from the information collected by UNESCO (United Nations Educational, Scientific and Cultural Organization) that every country considers science clubs for young people to be a valuable asset for the country, and official, semi-official or non-official bodies are anxious to give all possible help to these clubs. In India there is every reason to believe that science clubs will receive more public support as they develop and that the educators and industrialists of our country will be inclined to look towards them as effective centres for discovering talent and forming scientists of a high order.

You will be gratified to know that UNESCO is endeavouring to establish contacts with existing science clubs in all countries and is willing to act as a clearing house for the exchange of information and publications. For the purpose of international co-operation, you will want to know the addresses of science clubs in other countries, so that your own club members may exchange news and materials (such as specimens of insects or plants), or just to obtain information on methods used elsewhere. Enquiries of

any kind may be addressed to the Department of Natural Sciences, Division for Teaching and Dissemination of Science, UNESCO, 19 Avenue Kleber, Paris 16, France. For information of a more local nature, you may also write to the UNESCO Science Co-operation Office for South Asia, University Building, Delhi, India.

From Science Clubs of America, 1719 N Street, N.W. Washington, 6 D.C., U.S.A. you may ask for the Sponsor Handbook and other publications for sponsors of science clubs which will be sent to you free of charge.

A new era of international co-operation and mutual understanding is in sight. Ignorance and prejudice that are dividing peoples today will soon give place to knowledge and sympathy, and the world will be one. You have your own contribution to make. The pleasant and peaceful influence of India is needed in the task of restoring to science its rightful place as the presiding deity of plenty and prosperity leading to permanent peace.

APPENDIX I

ADDRESSES OF SCIENCE CLUBS

Australia.

— Numerous science, nature study, agricultural and gardening clubs ; not organized on a national scale.
For information : Department of Education,
Melbourne, Australia.

Canada

— Conseil Canadien des Cercles de Jeunes Agriculteurs,
79 Edifice de la Confederation.
Ottawa, Ont., Canada.

— Cercles de Jeunes Naturalistes,
Secretariat general : Jardin Botanique de Montreal,
4101 est, Rue Sherbrooke,
Montreal 36, P.Q., Canada.

— Clubs des Jeunes Gardes-forestiers,
509 Burrard Street,
Vancouver, B.C., Canada.

— Clubs 4-H du Quebec,
286 rue St. Joseph,
Quebec, P.Q., Canada.

— Audubon Society of Canada,
177 Jarvis St.,
Toronto 2, Ont., Canada.

Denmark

— Ungdommens Naturvidenskabelige Forening (Young People's Union for the Study of Natural Sciences)
ILL. FAMILIE JOURNAL,
Copenhagen, Valby, Denmark.

— Danish 4-H Clubs,
c/o Ministry of Agriculture,
Copenhagen, Denmark.

Finland.

— Luonto-Liitto (Federation of the Friends of Nature),
Mr. Jouko Haavisto,
Box 252,
Helsinki, Finland.

— 4-H Clubs of Finland,
c/o Ministry of Agricnlture,
Helsinki, Finland.

France.

— Jeunesse Astronomique de France,
17 rue E. Deutsch-de-la-Meurthe,
Pairs 14e, France.

— Groupe des Jeunes ornithologistes, c/o Ligue Fransaise pour la Protection des Oiseaux,
129 Boulevard Saint-Germain,
Paris, 6e, France.

— Societe des Sciences Naturellos de l'Quest de la France,
2 rue Athenas,
Nantes, France.

Germany.

— Deutscher Jugendbund fur Naturbeobachtung (D.J.N.),
(German Youth Society for the Study of Nature)
Rolf Neddermeyer,
Vor dem Neuemtore 23-B,
Luneburg, Germany.

Indonesia.

— "Sardjana Muda" (Sci. Clubs of Indonesia),
c/o Jajasan Pendidikan Masjarakat,
Salemba 4,
Post box 30,
Djakarta, Indonesia.

Belgium.

— Club Scientifique de Liege,
M. Ch. Jeuniaux, Administrateur-Delegue,
32 rue du Marche,
Liege, Belgium,

Holland.

— Hobby Clubs,
Mr. Leonard de Vries,
c/o "De Bezige Bij",
Miereveldstr. 1,
Amsterdam, Holland.

— Nederlandse Jeugbond voor
Natuurstudie (N.J.N.),
(Dutch Youth Society for the Study of Nature)
Rein van der Vegt, 1st Secretary,
Archimede Splantsoen 24,
Amsterdam, Holland.

India.

— Science Clubs of India,
Dr. G.M. Jadhav,
"Nirvan", Shivaji Road,
Baroda, India.

— Science Clubs for Girls,
Miss K. Sen, Principal,
Lady Irwin Higher Secondary School for Girls,
New Delhi, India.

Bombay.

— Scientific Inquirers Saifee Jubilee High School,
Sidhpur (North Gujrat).

— St. Xavier's High School Ahmedabad 1.

Madhya Pradesh.

— Government High School, Buldana.

— Swavalambi Vidyalaya, Wardha.

Madras.

— V.M. High School, Bodinayakanur.

— Board High School, Duddukar.

— High School, Katampazhipuram.

— Union Christian High School, Madhurai.

— Board High School Pakala (Chittor Dist.).

— Board High School, Papanasam P.O. (Tanjore Dist.).

— Government Secondary and Training School for Women, Tirur.

— Board High School, Sholavandau.

College Level Clubs.

Madras.

— The Zoology Seminar Government Arts College, Coimbatore.

Pepsu.

— Ramgarhia College, Phagwara.

— Scientific Hobbies Club, Ranbir College, Sangrur.

New Zealand.

— Numerous science, nature study, agricultural and gardening clubs ; not organized on a national scale.
For information : Department of Education,
Wellington C.I., New Zealand.

Pakistan.

— Science Clubs of Pakistan,
8 Sehwani Burns Road,
Karachi, Pakistan.

Sweden.

Sveriges Faltbiologisk Ungdomsforening (Swedish Field-Biology Youth Group) Class Thoren,
Kommendorsgatan 23,
Stockholm, Sweden.

Switzerland,

— Groupe des Jeunes de Nos Oiseaux,
M. Gerard de Crouzas,
Avenue des Gerisiers 13,
Pully-Lausanne, Switzerland.

United Kingdom.

— Amateur Entomologists' Society (has junior membership),
I West Ham Lane,
London, E, 15, England.

— Association of School Natural History Societies,
c/o British Museum (Nat. History),
Cromwell Road,
London, S.W. 7., England.

— Scottish Association of Young Farmers' Clubs,
11, Rutland Street,
Edinburgh, Scotland.

— Junior Bird Recorders' Club of the Royal Society for the Protection of Birds,
82, Victoria Street,
London, S.W. 1., England.

— National Federation of Young Farmers' Clubs,
55, Gower Street,
London, W.C. 1., England.

— Young Farmers' Clubs of Ulster,
18, Donegall Square East,
Belfast, Ireland.

United States of America.

— Science Clubs of America,
1719 N St., N.W.,
Washington 6, D.C., U.S.A.

— 4-H Club Movement,
c/o Department of Agriculture Extension Service,
Washington 25, D.C., U.S.A.

— Future Farmers of America, and New Farmers of America,
Agriculture Education Service,
U.S. Office of Education,
Washington 25, D.C., U.S.A.

— Audubon Junior Clubs,
1000 Fifth Avenue,
New York 28, N.Y., U.S.A.

Norway.

— Landslaget Norske Jordbruksklubber (Agricultural Clubs of Norway),
Kr. Augustgt. 15,
Oslo, Norway.

APPENDIX II

Tools.

For a science club, it is necessary that there must be a tool kit. The following tools are needed which can be purchased locally.

(1) One claw-hammer (2) One hand saw (3) One back saw (4) One coping saw (5) One jack plane (6) One soldering rod. (7) One hand drill with assorted drills (8) Two pliers (9) One chisel (10) A few screw drivers (11) One small level (12) One oil stove and a small can of oil (13) One vice (14) On awl (15) One try-square.

Care about tools.

(1) There must be a place for each tool.

(2) Each tool must be put back in its proper place when finished with it.

(3) All tools should be wiped with a light coat of oil to prevent rust.

In due course of time a science club should try to have at least two such tool kits.

The price of the above-mentioned list of tools will come to about rupees one hundred.

These Tools can be purchased locally.

In addition to the tools mentioned above, a workshop should be in possession of the following material : (a) nails (b) screws (c) wires of different metals (d) sheets of brass, tin and iron (e) wood (f) solder and soldering paste, and (g) wire gauze.

APPENDIX III

The following apparatus is needed for a science club, and the cost of the apparatus will be about rupees three hundred. This apparatus can be bought locally.

(1) Beakers (one dozen) (2) Test tubes ($\frac{1}{2}$ gross) (3) Test tube stands (4) Test tube holders (5) Flasks (four) (6) Spirit lamps ($\frac{1}{2}$ dozen) (7) Cork borers (8) Files (9) Assorted corks (one gross) (10) Pneumatic troughs (stone)—(two) (11) Gas jars (6) (12) Deflagrating spoons (three) (13) Bechive shelves (three) (14 Gas jar covers (dozen) (15) Pestle and mortar (two) (16) Spatula (two) (17) Crucibles (6) (18) Bell jars (two) (19) Balance ordinary (one) (20) Weight box (one) (21) Retort (one) (22) Rubber tube (23) Rubber corks (24) Bar Magnets (3) (25) Magnets horse-shoe (2) (26) Small compass needles (3) (27) Thermometers Centigrade (4) (28) Fahrenheit (1) (29) Asbestos sheet (30) Convex lens (6) (31) Concave lens (2) (32) Electric bells (3) (33) Metre rods (3) (34) Dry cells (6) (35) Glass tubes (assorted) (36) Torch bulbs (one dozen) (37) Kipp's apparatus (1) (38) Woulf's bottle (two) (39) Barometric tube (40) Porcelain dishes (3).

The following is the list of chemicals that are required for a science club in small quantities :—

(41) Strong sulphuric acid (42) Strong hydrochloric acid (42) Strong nitric acid (44) Caustic soda (45) Ammonia (46) Lime water (47) Magnesium (41) Phosphorous (49) Ferrous sulphide (50) Marble pieces (51) Magnesium sulphate (52) Baking soda (53) Iodine (54) Spirit (3 bottles) (55) Potassium chlorate (56) Manganese dioxide (57) Carbon tetrachloride (58) Sulphur (59) Mercury (60) Alum (61) Cobalt nitrate (62) Nickel sulphate (63) Copper sulphate (64) Manganese sulphate (65) Silver nitrate (66) Ammonium dichromate (67) Turpentine oil (68) Paraffin wax (69) Zinc (70) Blue litmus solution (71) Red litmus solution (72). Antimony chloride (73) Zinc sulphate (74) Methyl orange (75) Phenolphthalein (76) Ferrous sulphate (77) Lead

nitrate (78) Stannows chloride (79) Antimony chloride (80) Mercuric chloride (81) Oxalic acid (82) Glycerine (82) Iron filings (83) Common salt (sodium chloride) (84) Red oxide of mercury (85) Soda lime (86) Alcohol (one bottle) (87) Lead acetate (88) Acetic acid (89) Sodium silicate (90) Caustic potash (91) Acetone (92) Borax.

There are certain articles which can be purchased from time to time for different projects and these have not been listed above.

Some apparatus like a vacuum pump can be borrowed from an educational institution for a few days and returned in good condition after it has been used.